The Value of Mandatory Certification: A Real Effects Perspective*

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Abstract

We study the real effects of certification to demonstrate the value of mandatory certification over and above mandatory disclosure in enhancing investment efficiency. In our model, a firm's manager selects a project to maximize the firm's short-term stock price, which is a function of her certification and disclosure decisions about the outcome of the project. While the manager might be either forthcoming or strategic with regard to the disclosure of her private information (Beyer and Dye, 2012; Bertomeu and Marinovic, 2016), she can strategically choose whether to incur a cost or not to certify her disclosure, unless mandated. The manager always selects the first-best project when both certification and disclosure are mandatory. However, when certification is voluntary, project selection is inefficient. In addition, mandating disclosure without mandating certification can lead to lower investment efficiency than mandating neither. In justifying why mandatory certification is beneficial for public firms, our results offer a note of caution regarding the contemplated regulatory moves for increased disclosures by public firms without corresponding certification requirements, for example, the recent SEC proposal requiring extensive climate-related disclosure..

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1 Introduction

In this paper, we present a theory that explains why mandatory certification of financial reporting is necessary for publicly traded companies and why mandatory disclosure without mandatory certification is insufficient. In complementing the prevailing externality-based justifications (Leuz, 2010; Leuz and Wysocki, 2016), we offer an alternative explanation, demonstrating how mandatory certification of firms' financial reports affects their real investment decisions over and beyond mandatory disclosure.

Audited corporate financial reports are a form of certification, in that firms not only disclose their financial results but also have their results certified by external auditors. Certification makes information hard (Ijiri, 1975) and assures users of the reliability of the reported results (Ball, 2001; Ball et al., 2012). Thus, certified financial reports help alleviate inefficiencies due to incentive misalignment (Crawford and Sobel, 1982), reduce capital market frictions (Akerlof, 1970), and lower firms' costs of capital (Lambert et al., 2007). Academics (Chow, 1982; Watts and Zimmerman, 1983) and regulators (Harris, 2014) view such certification as fundamental to financial reporting.

However, certification incurs significant costs, including both direct costs (e.g., audit fees) and indirect costs (e.g., the costs associated with complying with audit rules). Both academics and practitioners argue that high certification costs place an undue burden on public firms, especially smaller ones. Coates and John (2007) and Coates and Srinivasan (2014) argue that the costs of complying with Section 404 of the Sarbanes-Oxley Act (SOX) are of particular concern for small firms. Moreover, Iliev (2010) finds that in 2004, compliance with SOX Section 404 increased the audit fees by a burdensome 98%, or US$697,890, which is not a small amount for a median firm in that year with market capitalization of US$110.9 million. High certification costs over the past decade are one of the reasons for both the decline in the number of new initial public offerings (IPOs) and the increase in the number of public firms choosing to go private (Djama et al., 2014; Gao et al., 2013). To facilitate companies' access to public capital markets, the U.S. Securities and Exchange Commission (SEC) proposed easing audit requirements for some companies in 2019(Rubin, 2019), which has been criticized by even its own commissioner for re-

sulting in a loss of investor confidence (Michaels, 2019). There has also been a strong push from the SEC to increase disclosure requirements without mandating the corresponding certification of such disclosures. For example, Subpart 1400 of Regulation S-K expands the disclosures that banking registrants are required to provide without mandating the corresponding audit requirements.[1] The SEC is also considering proposals to mandate environmental, social, and governance (ESG) disclosures in firms' annual reports. However, there is no discussion about the verification requirements of such disclosures.[2]

A straightforward argument for not requiring mandatory certification is as follows: mandatory certification is not necessary if firms can internalize the costs and benefits associated with certifying their financial statements. Such internalization results in firms with net benefits from certified disclosure choosing to issue certified financial reports on a voluntary basis. In such cases, there is no incremental value of mandatory certification over and above mandatory disclosure. However, in their survey, Minnis and Shroff (2017) show that most private firms perceive the private costs of certification to be greater than the private benefits of certification. This suggests that these firms will not provide certified disclosures unless they are required to do so, which may be one reason why they do not go public.[3]

The need for the mandatory certification of financial disclosure can be rationalized in two ways. First, *certified* disclosure results in positive externalities that firms often fail to internalize (e.g., Leuz, 2010; Leuz and Wysocki, 2016); here, externality refers to the financial statements of one firm facilitating other firms' decision making or improving investors' valuation of other firms. Second, such certification reduces agency costs. For instance, Shroff (2020) finds that the Public Company Accounting Oversight Board's (PCAOB) international inspection programs re-

[1]The final rules, *Update of Statistical Disclosures for Bank and Savings and Loan Registrants*, state the following: "[W]e did not propose to require the disclosures required by new Subpart 1400 of Regulation S-K to be presented in the notes to the financial statements. Therefore, if disclosures are provided outside the financial statements, the disclosures would not be required to be audited (SEC, 2020, p.7)".

[2]According to a report issued by the Center for Audit Quality (CAQ), only 264 of the companies included in the S&P 500 index use an outside firm to verify at least some of their ESG numbers, and only 31 of those 264 companies have their climate data verified by accounting firms (Eagelsham, 2021). Another report from CAQ states that merely 6% of S&P 500 companies receive assurance from a public company auditing firm over some of their ESG information. See https://www.thecaq.org/sp-500-and-esg-reporting/.

[3]See DeFond and Zhang (2014) for how firms may benefit from and thus demand auditing.

duce companies' financing constraints and improve companies' investment decisions by reducing agency costs. Although such justifications are intuitively appealing, they also raise the question of why all firms, public and private, are not required to provide certified financial reports, particularly because both public and private firms experience positive externalities and have agency costs.[4]

We offer an alternative justification for mandatory certified financial reporting. We present an investment model that explicitly considers the real effects of certification and disclosure (Kanodia et al., 2007; Kanodia and Sapra, 2016): a firm's investment is endogenous to its *subsequent* certification and disclosure choices because these choices affect investors' conjectures on the firm's investment decisions and, consequently, the pricing of the firm. Specifically, a firm's manager chooses between two investment projects – one risky, and the other risk-free. The risky project yields a high and positive return if it succeeds but a zero return if it fails. The risk-free project generates a constant return that is higher than the *expected* return but lower than the possible high return of the risky project, thereby making the risk-free project the first-best investment. After choosing an investment project, as in Dye (1985) and Jung and Kwon (1988), the manager receives evidence about the project's outcome with some probability.

To differentiate between mandatory disclosure and mandatory certification, following the literature (Beyer and Dye, 2012; Bertomeu and Marinovic, 2016; Liang, Marinovic, and Varas, 2018), we assume that there are two types of managers: a forthcoming type who always truthfully discloses the received evidence regardless of whether disclosure is mandated, and a strategic type who chooses to disclose the received evidence strategically (i.e., withhold, report truthfully, or misreport the evidence). However, both types of managers are free to choose whether to certify their disclosure when certification is not mandated. Furthermore, we consider three regulatory regimes: a *mandatory certification regime* in which both certification and disclosure are manda-

[4]While it is true that private firms in countries such as the United Kingdom (UK) are also required to provide certified financial reports under the UK Companies Act, as discussed in detail in Ball and Shivakumar (2005), only public firms are required to do so in the United States (US) and Canada. Our real-effects perspective is consistent with this practice, to the extent that the managerial myopia stemming from capital market pressure is more prevalent in the US and Canada than in the UK.

tory, a *mandatory disclosure regime* in which certification is voluntary but disclosure is mandatory, and a *voluntary regime* in which both choices are voluntary (a forthcoming manager, however, always truthfully discloses the received evidence).[5] Consistent with Dye (1985) and Jung and Kwon (1988), disclosure does not incur any explicit cost. In contrast, we assume that evidence certification bears an explicit cost, which can be interpreted as an audit fee or management time cost. After a project is selected and certification/disclosure decisions are made, the manager's payoff is realized, which is the selling price of the firm conditional on the manager's disclosure (certified or not) or lack thereof.

We find that while the most regulated mandatory certification regime always achieves the highest level of investment efficiency, mandating disclosure without mandating certification may result in even lower investment efficiency relative to mandating neither disclosure nor certification (a.k.a. laissez-faire). This finding demonstrates the incremental value of mandatory certification over and above mandatory disclosure, and it justifies the joint mandates of disclosure and certification, which, to the best of our knowledge, is not established in the literature.[6]

The intuition of the above results is related to the broader argument seen in Dye and Sunder (2001) and Bertomeu and Cheynel (2015). These papers show that *the decision to adhere to* a particular standard can convey information above and beyond *the content* of the disclosure as stipulated by the standard under consideration. In our setting, there are two channels through which information is conveyed: (i) via the manager's decision to disclose and certify a financial report and (ii) via the financial report itself. If both disclosure and certification are mandatory, the channel through which information is conveyed via the manager's disclosure and certification decisions shuts down. Consequently, investors set the short-term price to be equal to the expected equilibrium cash flows, conditional on the certified financial report or lack thereof. The risk-free

[5]There is another regime in which certification is mandatory but disclosure is voluntary. We show in Section OA1 of the Supplementary Appendix (online) that this regime is always associated with higher investment efficiency than the voluntary regime, suggesting that certification is key to improving investment efficiency.

[6]Versano (2021) demonstrates that the disclosure mandate is counter-productive in an agency setting if the disclosed information is soft (i.e., not entirely verifiable in an audit), because a disclosure mandate leads to managerial manipulation of such soft information disclosure that reduces the information content of the disclosure itself. In our model, evidence can be perfectly verified, and thus any certified disclosure must be truthful. We demonstrate the potential undesirability of the sole disclosure mandate in a capital market setting with investment.

project, which yields higher expected cash flows, is thus always selected in equilibrium, leading to first-best investment efficiency.[7]

However, if the manager can freely choose to disclose and certify her evidence (in either the mandatory disclosure regime or the voluntary regime), the information channel of the manager's disclosure and certification decisions opens up, as these decisions are conditional on her preceding project selection and her received evidence. Investors, therefore, rationally make inferences about the expected cash flows from both the specific financial report (or lack thereof) and the manager's certification and disclosure decisions. In anticipation of investors' price responses, the manager strategically chooses the project in which to invest, and this project selection often leads to inefficient investments (see also Ben-Porath et al., 2017; Guttman and Meng, 2021).

To understand why mandating disclosure (without simultaneously mandating certification) can result in higher levels of investment distortion, consider the two key frictions present in our least regulated voluntary regime. The first friction is the option of non-disclosure even when the evidence is present (Dye, 1985; Jung and Kwon, 1988). Owing to the uncertain nature of a manager's information endowment, non-disclosure arises either from an uninformed manager (either forthcoming or strategic) or from a strategic manager who selects the risky project and receives unfavorable evidence. The second friction is the option of not certifying the disclosure, which leads to the imperfect credibility of uncertified disclosures. Upon observing an uncertified disclosure, investors are uncertain whether the report is issued by a forthcoming manager who refrains from certification because it is too costly, or by a strategic manager who potentially misrepresents the evidence.

The replacement of the voluntary regime with the regulated mandatory disclosure regime directly removes the first friction: investors correctly interpret any non-disclosure situation as one in which the manager receives no evidence. However, by losing the option to withhold information, the strategic manager is tempted to invest in the risky project so that in case it succeeds, she can disclose and certify the favorable evidence; in case it fails, she can (mis)report

[7] This result is related to that in Jiang and Yang (2021) that document first-best investment efficiency can be achieved when managerial private benefit is sufficiently small through appropriately adjusting contract.

the outcome of the risk-free project. This potential (mis)reporting reduces the price response to the uncertified disclosure of the outcome of the risk-free project. The forthcoming manager thus finds it undesirable to stick to the risk-free project if it becomes too costly to certify the outcome; instead, she may switch to the risky project, disclose whatever evidence received, but certify only the favorable evidence. Overall, through its direct effect on the first friction and indirect effect on the second friction, the disclosure mandate can reduce efficiency.

The comparison of social welfare outcomes involves a trade-off between investment efficiency and (wasteful) certification costs. Echoing the reduction in efficiency caused by the disclosure mandate, we find that the mandatory disclosure regime never outperforms both the mandatory certification and voluntary regimes in terms of social welfare.

Our study has several empirical and policy implications. First, we show that while mandating both disclosure and certification always achieves the highest investment efficiency, mandating disclosure without mandating certification may result in an even lower investment efficiency than having no mandate at all, thereby demonstrating that mandatory certification, by enhancing the reliability of financial reports, is essential for efficient investment. This insight justifies mandating certified financial reports for firms that are prone to capital market pressure (e.g., publicly traded firms in which concerns about reliance on short-term prices to direct managerial decisions are pervasive).[8] Second, we find a non-monotonic relationship between certification cost and investment efficiency in both the mandatory disclosure and voluntary regimes. Essentially, sufficiently high or low certification costs result in the highest (i.e., first-best) level of efficiency, whereas moderate certification costs lead to lower levels of efficiency. Similarly, the relationship between certification cost and social welfare exhibits a non-monotonic pattern. Therefore, when firms opt for certification endogenously, the regulator's intention to lower certification costs could unintentionally harm investment efficiency and, furthermore, reduce social welfare.

[8]Firm listing status (public versus private) is just one of the many proxies for managerial myopia resulting from capital market pressure. Certain events, such as an IPO or option vesting, also capture managerial myopia. Private firms seeking a new bank loan or trying to maintain covenant requirements of the existing loans may also be subject to capital market pressure. The implications of our theory hold generally in settings wherein firms encounter high levels of managerial myopia.

Third, our welfare analysis illustrates a trade-off between investment efficiency and certification cost. While mandatory certification removes managers' ex-post discretion over disclosure and/or certification, resulting in an ex-ante efficient investment, it increases the certification cost, as firms must certify their disclosures. This trade-off differs from those in the auditing literature in which an auditor improves investment efficiency by alleviating information asymmetry or agency conflicts between stakeholders and managers. As certification costs should be lower than investment returns, our welfare analysis confirms the value of mandatory certification. Finally, we find that in regimes with voluntary certification, a monopolistic certifier charges a higher certification fee than in a competitive auditing market, which could improve investment efficiency. This improved efficiency suggests that introducing competition into the auditing market does not necessarily alleviate the inefficiency caused by voluntary certification.

Related Literature. Our study contributes to the literature on disclosure and auditing regulations; see Leuz and Wysocki (2016) for a comprehensive review of this literature. In contrast to the standard externality (Ross, 1979; Foster, 1980; Dye, 1990; Admati and Pfleiderer, 2000)[9] and cost-saving arguments for regulation (Mahoney, 1995), we argue that mandatory certified disclosure can improve investment efficiency relative to the regime in which disclosure certification is voluntary. To the best of our knowledge, our finding that mandatory disclosure without mandatory certification can lead to more undesirable consequences than voluntary disclosure and certification is absent in the literature.

Our study is also related to the literature on the strategic disclosure of hard information; see Stocken (2013) for a summary of this literature. Our assumption that evidence can be objectively verified and certified at a cost by an external party (which renders soft information hard) and reported to the public is consistent with the notion of hard information by Bertomeu and Marinovic (2016). However, we explore different questions. Whereas Bertomeu and Marinovic (2016)

[9] A notable exception is Bertomeu et al. (2021), who argue that mandatory disclosure is beneficial because it alleviates the negative externality of disclosure costs. While Bertomeu et al. (2021) focus on whether disclosure should be mandatory when disclosure is always costly, we focus on whether certification should be mandatory when (uncertified) disclosure is costless, and we explicitly consider a real effects setting.

focus on the interaction between the strategic disclosure of exogenously given hard and soft information, we explore the interaction between investment choices and strategic disclosure and certification of information that is only manipulable (i.e., soft) in the absence of certification.

Similar to our findings, Ben-Porath et al. (2017) and Guttman and Meng (2021) find that a manager's control of information disclosure leads to inefficient investment when she is not always informed. However, these papers do not differentiate between certification and disclosure because in their model, disclosure is assumed to be truthful. As such, their model does not address our study's core issues, which are as follows: whether and how certification works differently from disclosure in promoting investment efficiency, whether certification should be mandatory in addition to mandatory disclosure, and how certification costs affect investment decisions.

Broadly speaking, our study is also related to the literature on the real effects of financial markets on corporate decisions (e.g., Lambert et al., 2007; Bond et al., 2012). Our study contributes to the literature by investigating how the interaction between certification and disclosure affects firms' real investment decisions in economies (Kanodia and Sapra, 2016), which to the best of our knowledge is not addressed. We emphasize that the risk-shifting incentive arises from the manager's focus on short-term prices. However, we hesitate to posit that the intuition regarding riskiness of an investment can be directly applied to the investment decision problem as in the Kanodia real effects literature, who focus on the investment amount. Moreover, whereas most of the literature focuses on investment behavior in the presence of unobservable profitability, we focus on investment behavior in the case of unobservable project selection (Gigler et al., 2014).[10]

Other studies on voluntary disclosure and investment, such as Beyer and Guttman (2012), Wen (2013), and Dye (2017), assume that a manager can voluntarily choose to be silent, but any disclosure must be truthful. In contrast, disclosure in our paper is not necessarily truthful, which diminishes the credibility of uncertified disclosure, whether voluntary or mandatory. By separating disclosure and certification, we demonstrate the importance of certification in promoting

[10]For example, Kanodia and Lee (1998) emphasize the need for periodic performance reports by demonstrating that such reports alleviate the overinvestment problem stemming from information asymmetry on profitability. In our study, mandatory certified disclosure alleviates the inefficient project selection problem due to an inability to observe managers' project choices.

investment efficiency, as well as the economic value of mandating certification in addition to mandating disclosure.

2 Model Setup

We study a model in which a firm manager selects a project and makes subsequent disclosure and certification decisions regarding the project outcome. Figure 1 illustrates the sequence of events and the model is introduced in detail below.

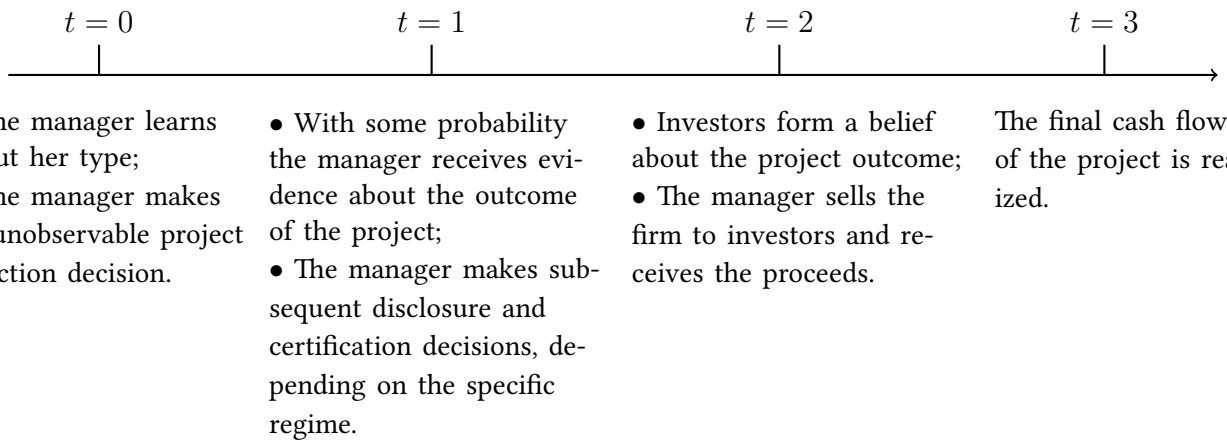


Figure 1: Timeline

Firm Manager. A firm's manager chooses a project at $t = 0$ and makes the subsequent disclosure and certification decisions at $t = 1$ to maximize the $t = 2$ proceeds from firm sales net of the certification cost (to be specified shortly), if any. The proceeds depend on investors' evaluation of the firm value. Both the firm manager and investors are risk-neutral. The initial value of the firm is normalized to zero, and therefore, the firm price at $t = 2$ is equal to the expected value of the investors' conjecture of the project selected by the manager. The manager's disclosure and certification decisions determine the information available to the investors, on the basis of which the investors assess firm value.[11]

[11]The assumption that the manager's payoff depends solely on investors' perceptions (rather than the realized value of the selected project) highlights that the manager is concerned with how the financial market responds to

The manager falls into one of two types. With probability $\theta \in (0, 1)$, the manager is a strategic type, whereas with complementary probability $1 - \theta$, the manager is a forthcoming type (Beyer and Dye, 2012; Marinovic, 2013; Bertomeu and Marinovic, 2016; Liang et al., 2018). Beyer and Dye (2012, p. 883) justify a manager's forthcoming behavior by arguing that "in some periods, the manager may recognize that the effectiveness of the firm's internal controls, or the scrutiny by the firm's auditors, or by outside news organizations is so great that he responds by behaving as forthcoming." In our model, the strategic type and the forthcoming type are denoted by S and F, respectively. The manager knows her type privately. The two types differ in the following ways: F cannot withhold or misreport evidence, whereas S can do both, suggesting that as long as F receives evidence, she has to disclose this evidence truthfully to investors, and the only discretion she can exercise is in choosing whether to certify the evidence. The existence of the forthcoming type of manager lends credibility to uncertified disclosure, which enables us to assess the differing roles of disclosure and certification mandates.

Project Selection. The firm's manager can privately choose between two projects (i.e., a risk-free project and a risky project) at $t = 0$. The risk-free project yields a certain payoff normalized to 1. The payoff of the risky project is uncertain: with probability $p \in (0, 1)$, the risky project succeeds and yields $V > 1$, whereas with complementary probability $1-p$, it fails, and the payoff is 0. The risk-free project is assumed to generate a higher expected payoff (i.e., $pV < 1$), thereby making it the *first-best* project. We further confine our attention to a more relevant scenario in which the risky project is sufficiently attractive to the manager by assuming that $V > \underline{V}$, where $\underline{V} \equiv \max\{\frac{1}{p} - \frac{\theta(1-p)^2}{p(1-p\theta)}, 2 - p\}$.[12]

the firm's choices. Alternatively, the manager can represent the interests of current shareholders and is therefore concerned about current stock prices. This form of managerial myopia is widespread in publicly listed firms and is a common assumption in the literature (e.g., Kanodia and Sapra, 2016; Ben-Porath et al., 2017). Our key result remains robust as long as the manager's payoff places a sufficiently large positive weight on the firm's short-term stock performance; see Section 4.2 for a detailed discussion.

[12]Intuitively, the risky project needs to generate high return upon success (i.e., high V), such that the manager faces a non-trivial trade-off between the efficient risk-free project and the inefficient risky project. The specific threshold for V (i.e., $\underline{V}$) is determined by deriving the equilibrium in Lemma 2 in Section 3. Only when $V > \underline{V}$ can it be sustained in equilibrium that both types of managers choose the risky project in the mandatory disclosure regime. As is clearly stated in Section 3, this inequality constitutes a necessary condition for our novel result that the

Disclosure and Certification. At $t = 1$, following Dye (1985) and Jung and Kwon (1988), the manager receives evidence about the outcome of the selected project with probability $q \in (0, 1)$, and no evidence about the outcome of the project with complementary probability $1 - q$. Only when the manager receives evidence can she make a disclosure (truthful or not); otherwise, she cannot reveal anything to investors.[13] If the manager is the forthcoming type, her disclosure is truthful, but if she is the strategic type, her disclosure may or may not be truthful. Having decided to disclose the evidence to investors, the manager further determines whether to certify her disclosure. Certification makes the disclosed evidence credible, but it comes at a cost of $c > 0$. This amount can be associated with the cost of hiring auditors or with the indirect cost of complying with existing accounting rules. Alternatively, the cost reflects how well the evidence about the project can be credibly disclosed to outside investors (i.e., the verifiability of the information). We further focus on the parameter region with relatively low certification costs, that is, $c < V - 1$; otherwise, if the certification costs are prohibitively high (i.e., $c \geq V - 1$), both types of managers always choose the risk-free project, thereby rendering irrelevant the examination of the effect of disclosure/certification mandates.

Three Regulatory Regimes. We consider the following three regulatory regimes to examine the difference between disclosure and certification mandates:

(1) *Mandatory certification regime*: Both F and S must disclose and certify any evidence they receive.

(2) *Mandatory disclosure regime*: Both F and S must disclose evidence whenever they receive it but can decide freely whether to certify the disclosure. Whereas F must disclose the received evidence truthfully, S's disclosure may or may not be truthful.

(3) *Voluntary regime*: On receiving evidence, S can decide whether to make a disclosure (truthful

disclosure mandate alone reduces investment efficiency. Moreover, $\underline{V}$ is a function of p that reflects the attractiveness of the risky project to the manager, and a function of θ that affects firm valuation via its effect on investors' belief of the manager types.

[13] Allowing S's false disclosure even when she receives no evidence does not change our results; see Section 4.1 for more details.

or not) and, if so, whether to certify the disclosed evidence. Although certification is at F's discretion, she always discloses the received evidence truthfully.

In brief, regulation becomes progressively stricter from the voluntary regime to the mandatory disclosure regime, and further to the mandatory certification regime.

Equilibrium Definition. The setting is defined by a tuple of five exogenous parameters, namely, $\mathcal{E} \equiv \{\theta, p, q, V, c\}$. The equilibrium concept we use is the Perfect Bayesian equilibrium, which is defined as follows: (i) two investment strategies at $t = 0$ that maximize the respective expected final payoff of the forthcoming manager type and the strategic manager type; (ii) two disclosure/certification strategies at $t = 1$ that maximize the respective expected final payoff of the forthcoming manager type and the strategic manager type, given their respective $t = 0$ investment strategies, and possibly any private information about the project's outcome; (iii) investors' posterior beliefs about the firm value as a function of their priors and, if applicable, the manager's disclosure (certified or not), using Bayes' rule wherever possible; and (iv) investors' rational expectations in the sense that in equilibrium, their beliefs about the strategies of each type of manager are consistent with the respective type of manager's actual strategies. When multiple equilibria exist, we choose the equilibrium that is preferred by the manager (i.e., the manager's Pareto-dominant equilibrium).[14]

3 Certification and Disclosure Mandates

In this section, we first characterize the equilibrium in each regulatory regime, and then compare the three regimes to gauge the effects of certification and disclosure mandates.

[14] Given that the manager is the first mover in the game, such a selection criterion derives its intuitive theoretical underpinning from the Perfect Sequential Equilibrium (Grossman and Perry, 1986; Bertomeu and Marinovic, 2016).

3.1 Equilibrium in Each Regulatory Regime

3.1.1 Mandatory certification regime

We first examine the mandatory certification regime in which the manager is required to disclose and certify any of the evidence she receives. The following lemma characterizes the equilibrium in this regime.

Lemma 1 (Mandatory certification regime)**.** *In the mandatory certification regime, there is a unique equilibrium in which both F and S select the risk-free project and disclose and certify the received evidence* 1*.*

In the mandatory certification regime, forcing the manager to disclose and certify the evidence she receives removes any information contained in the manager's *decision* to disclose and/or certify the evidence. Essentially, non-disclosure is rationally interpreted as the manager receiving no evidence. Therefore, as shown in Lemma 1, to maximize the expected firm value, the manager simply selects the project with the highest expected value, consistent with the investors' perceptions.

3.1.2 Mandatory disclosure regime and voluntary regime

We now study the regimes with voluntary certification, including the mandatory disclosure regime and the voluntary regime. Lemmas 2 and 3 summarize the respective equilibria in these two regimes. Readers who want a visual illustration of the equilibria can skip these lemmas and go directly to Figure 2 in Section 3.2 directly.

Lemma 2 (Mandatory disclosure regime)**.** *Let* $\underline{c} \equiv \frac{1-pV}{1-p}$ *and* $\bar{c}^{MD} \equiv V - \frac{1}{p}\frac{1-\theta}{1-\theta p}$*. The equilibrium in the mandatory disclosure regime is characterized as follows.*

(1) *If* $c \leq \underline{c}$*, both F and S select the risk-free project and disclose and certify evidence* 1*.*

(2) *If* $\underline{c} < c < \bar{c}^{MD}$*, both F and S select the risky project and disclose and certify evidence* V *while disclosing, without certifying evidence* 0*.*

(3) *If* $\bar{c}^{MD} \leq c < V-1$, *F selects the risk-free project and discloses without certifying evidence* 1*; S selects the risky project and discloses and certifies evidence* V*, while misreporting* 1 *without certifying evidence* 0.

Lemma 3 (Voluntary regime). *Let* $\underline{\underline{c}}^V \equiv \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)}$, $\underline{c} \equiv \frac{1-pV}{1-p}$, *and* $\bar{c}^V \equiv \max\{V - \frac{1-\theta+pV(1-q)\theta}{p(1-pq\theta)}, \frac{\theta(1-pV+pq(V-1))}{1-pq\theta}\}$. *In the voluntary regime, the equilibrium is characterized as follows.*

(1) *If* $c < \underline{\underline{c}}^V$, *F selects the risk-free project and discloses and certifies evidence* 1. *S randomizes between the risk-free and risky projects and discloses and certifies evidence 1 or* V *while withholding evidence* 0. *The probability of S selecting the risk-free project,* $\tau_S \in (0,1)$, *is denoted by (A12) in the appendix.*

(2) *If (2.1)* $\underline{\underline{c}}^V \leq c \leq \underline{c}$ *or (2.2)* $c \geq \bar{c}^V$, *F selects the risk-free project and S selects the risky project. Under Condition (2.1), F discloses and certifies evidence* 1*; S discloses and certifies evidence* V *while withholding evidence* 0. *Under Condition (2.2), F discloses but does not certify evidence* 1*; S discloses and certifies evidence* V *while randomizing between misreporting* 1 *without certification and withholding information after receiving evidence* 0. *The probability of S misreporting* 1 *after receiving evidence* 0, $\psi \in (0,1)$, *is denoted by (A17) in the appendix.*

(3) *If* $\underline{c} < c < \bar{c}^V$, *both F and S select the risky project. While both F and S disclose and certify evidence* V, *F discloses but S withholds evidence* 0.

As shown in Lemmas 2 and 3, characterizing the equilibria in the mandatory disclosure and voluntary regimes is complex because the complete description of each equilibrium includes multiple cases and various elements. We hereby summarize the key features of the two equilibria, focusing on the similarities and differences across the two regulatory regimes.

In both the mandatory disclosure and voluntary regimes, F chooses the risk-free project for low and high certification costs whereas she chooses the risky project for intermediate costs. When the certification cost is low (i.e., $c < \underline{c}$), F can afford to always certify her disclosures, which nullifies investors' possible skeptical conjectures regarding her project selection (i.e., conjecture that F chooses the risky project); F therefore, chooses the first-best risk-free project. As

the certification cost increases, choosing the risk-free project and always certifying the received evidence 1 becomes increasingly costly. When the certification cost exceeds $\underline{c}$, it is no longer optimal for F to always certify evidence 1 to sustain the (correct) price response to her disclosure of 1. Therefore, F switches to one of the following two options to save on future certification costs: choosing the risk-free project without certifying any evidence, or choosing the risky project and certifying only evidence V. When the certification cost is intermediate (i.e., $\underline{c} < c < \bar{c}^{MD}$ or $\underline{c} < c < \bar{c}^{V}$), reducing the certification cost is not the dominant consideration for F. Thus, F chooses the risky project with partial certification. However, when the certification cost is high (i.e., $c \geq \bar{c}^{MD}$ or $c \geq \bar{c}^{V}$), reducing the certification cost becomes the dominant consideration for F, prompting her to invest in the risk-free project without certifying any evidence.

Another similarity between the mandatory disclosure and voluntary regimes is that when the certification cost is high so that F chooses the risk-free project but does not certify her evidence at all, S, while choosing the risky project, can mimic F by issuing an uncertified disclosure of 1 if the project fails.

The distinguishing feature in the equilibria of the mandatory disclosure and voluntary regimes is S's project selection and subsequent disclosure/certification strategies when the certification cost is low (i.e., $c < \underline{c}$). In this scenario, while F's "always-certify strategy" eliminates S's incentive to (mis)report 1 without certification in both the mandatory disclosure and voluntary regimes, S's incentive to undertake the risky project differs in the two regimes. In the mandatory disclosure regime, as S cannot pretend to be uninformed when evidence is received, she optimally chooses the risk-free project and certifies her received evidence just as F does. In contrast, in the voluntary regime, the possibility that F may not receive any evidence and must therefore stay silent provides S with a camouflage to mimic the uninformed F even if she invests in the risky project and receives evidence 0. Consequently, S is enticed to always choose the risky project, at least with some positive probability, in the hope that the risky project succeeds. The probability that S chooses the risky project increases in the certification cost c because an increase in c reduces the payoff from investing in the risk-free project and always certifying the evidence.

3.2 The Effects of Disclosure and Certification Mandates

Having presented the equilibrium in each regulatory regime in Lemmas 1, 2, and 3, we examine the effects of the disclosure and certification mandates on investment efficiency, which is defined as the expected value of the selected project. Proposition 1 summarizes the main results.

Proposition 1 (Effects of disclosure and certification mandates)**.** *The ranking of the three regulatory regimes in terms of investment efficiency, is as follows:*

(1) *If* $c < \underline{c}$*, mandatory certification regime* $=$ *mandatory disclosure regime* $>$ *voluntary regime.*

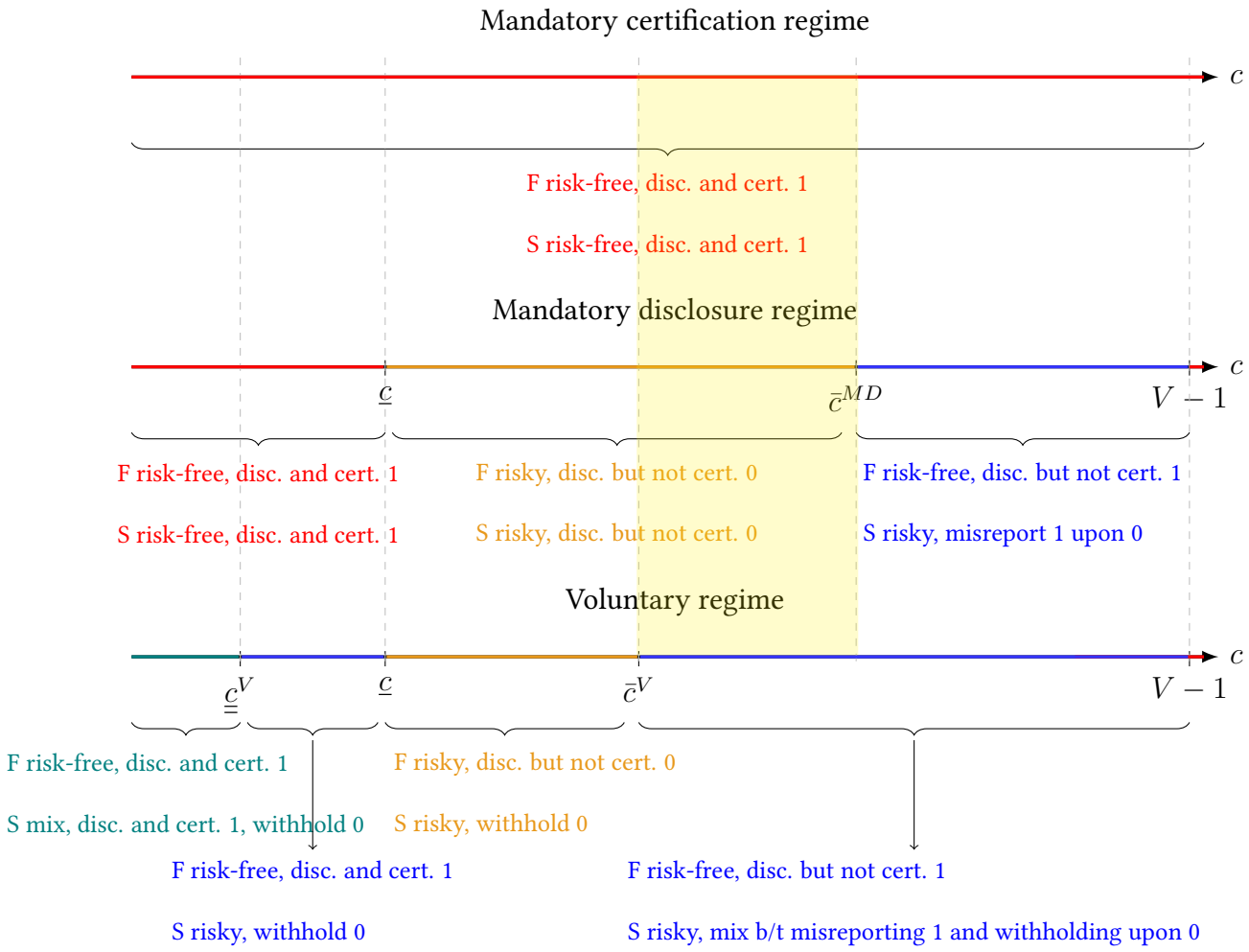
(2) *If (2.1)* $\underline{c} \leq c < \bar{c}^V$ *or (2.2)* $\bar{c}^{MD} \leq c < V - 1$*, mandatory certification regime* $>$ *mandatory disclosure regime* $=$ *voluntary regime.*

(3) *If* $\bar{c}^V \leq c < \bar{c}^{MD}$*, mandatory certification regime* $>$ *voluntary regime* $>$ *mandatory disclosure regime.*

Figure 2 graphically illustrates Lemmas 1–3 and Proposition 1.[15] When plotting, we follow Assumption 1 to ensure that all possible types of equilibrium project selection characterized in Lemmas 1–3 arise in equilibrium. Note that there are other scenarios (in violation of Assumption 1) that make some of the identified equilibria irrelevant, that is, the parameter sets in support of such equilibria are empty. In Section OA2 of the Supplementary Appendix (online), we plot these other representative equilibrium patterns to demonstrate the robustness of our key result.

Assumption 1. $\underline{c} < \bar{c}^V < \bar{c}^{MD} < V - 1$ *and* $\underline{\underline{c}}^V > 0$.

[15] The disclosure and certification decisions about evidence V are not specified in Figure 2 because the range of certification costs on which we focus, namely, $c \in (0, V - 1)$, ensures that both F and S always find it optimal to disclose and certify V. A certified report of V thus nullifies investors' contrary conjectures except when the risky project has been selected and is successful, which increases the price response to V. Furthermore, an uncertified disclosure of V is not credible and is rationally discounted by investors to 0 due to potential misreporting by S.



This figure presents the equilibrium project selection by the two types of managers and their disclosure/certification decisions regarding the received evidence in the mandatory certification regime, the mandatory disclosure regime, and the voluntary regime, as shown in Lemmas 1, 2 and 3, respectively. The evidence V is always disclosed and certified. The shaded area plots the region in which the voluntary regime dominates the mandatory disclosure regime in terms of investment efficiency. The parameters used to draw the figure are: $p = 0.15, q = 0.5, \theta = 0.8$, and $V = 3.8$, which are consistent with Assumption 1.

Figure 2: Investment efficiency and disclosure/certification decisions across different regimes

Proposition 1 and Figure 2 demonstrate the study's key message: when the certification cost is low (i.e., $c < \underline{c}$), the disclosure mandate alone is sufficient to achieve the first-best investment efficiency; however, as the certification cost increases, the disclosure mandate may not improve investment efficiency compared with no mandate and may even reduce investment efficiency for intermediate certification costs. Combined with the fact that the mandatory certification regime is

always associated with the first-best investment efficiency, these results justify the joint mandates of disclosure and certification.

To demonstrate the underlying economics of this main result, we start the analysis with the least regulated voluntary regime, in which two key frictions are present. The first is the option of not disclosing anything even when evidence is present (i.e., the imperfect credibility of non-disclosure or the Dye friction; see Dye, 1985; Jung and Kwon, 1988), which applies to S. The second is the option of not certifying the disclosure (i.e., the imperfect credibility of uncertified disclosure), which applies to both F and S.

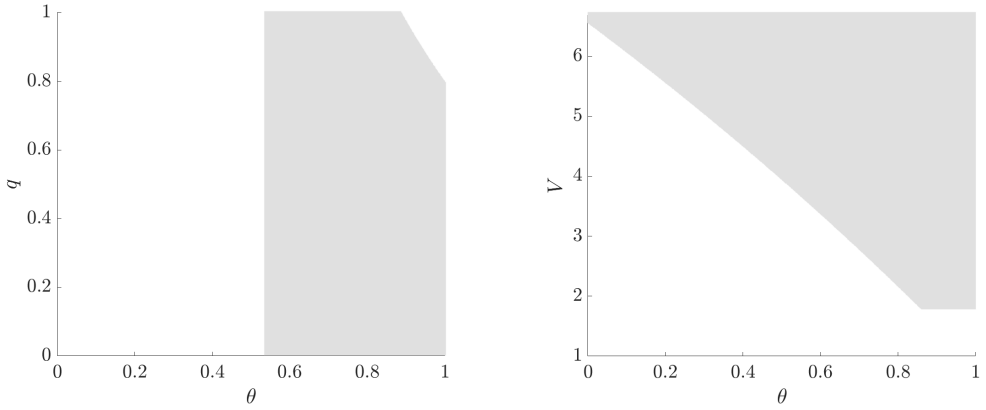
The disclosure mandate directly removes the first friction; that is, S, once informed, cannot pretend to be uninformed. When the certification cost is low, as F always certifies her disclosure to sustain her first-best project selection, the imposition of the disclosure mandate forces S to choose the first-best risk-free project and certify her disclosure as well. If S chooses the risky project and receives the unfavorable evidence 0, it is no longer feasible for her to deceive investors into believing that she has invested in the risk-free project by either staying silent or issuing an uncertified (mis)report of 1.

However, as certification costs increase, F no longer finds it optimal to choose the risk-free project and always certify evidence 1 (if received), enabling S to issue an uncertified report of 1 to disguise the observed failed risky project. As a result, S is tempted to choose the risky project even if disclosure is mandatory. Therefore, mandating disclosure alone (without mandating certification) is insufficient in achieving the first-best investment efficiency.

Moreover, imposing the disclosure mandate deprives S of the option to stay silent when the unfavorable evidence 0 is received and entices her to misreport 1, prompting investors to discount, to a larger extent, the uncertified report of 1 relative to the lack of a mandate (i.e., the voluntary regime). Recall that F has two options: retaining the risk-free project without certifying evidence 1 or deviating to the risky project and certifying evidence V only. She optimally trades off a low-price response to the uncertified but truthful report of 1 and a high-price response to the certified report of V, net of the certification cost if the risky project succeeds. The muted

price response to the uncertified report of 1 resulting from the disclosure mandate reduces F's incentive to invest in the risk-free project. When the certification cost is excessive, F switches to the risky project and discloses and certifies evidence V only. Overall, while the disclosure mandate directly eradicates the credibility issue of non-disclosure, it could exacerbate the credibility issue of uncertified disclosure, and impair, rather than improve, investment efficiency.

Next, we conduct numerical analysis to examine how changes to some key parameters of the model could affect the likelihood of observing an inefficient disclosure mandate. The gray areas in Figure 3 plot the regions in which the disclosure mandate alone (without the certification mandate) reduces investment efficiency in the parameter spaces of (q, θ) and (V, θ).



(a) (q, θ) (b) (V, θ)

The gray areas in Panels (a) and (b) of this figure plot the regions in which the mandatory disclosure regime is associated with lower investment efficiency than the voluntary regime in the parameter spaces of (q, θ) and (V, θ), respectively. The parameters are $p = 0.15, q = 0.5$, and $V = 3.8$, except for the variant ones in each panel.

Figure 3: Inefficient disclosure mandate

Two observations from Panel (a) of Figure 3 are noteworthy. First, to observe an inefficient disclosure mandate, θ cannot be too low. This condition is intuitive as θ represents the probability that a manager is of the strategic type and is thus associated with the severity of certification-induced friction – a higher θ (lower than 1) indicates more serious credibility concerns about the manager's uncertified disclosure. If θ is very low, it is highly likely that an uncertified report of 1 is from F and, as a result, investors only slightly discount such a report. The effect of the

disclosure mandate on F's investment is therefore muted.

Second, whereas θ significantly affects the likelihood that we observe an inefficient disclosure mandate, the effect of q – the uncertainty about the manager's information endowment – is somewhat limited. As shown in Panel (a), for a wide range of θ, the variation in q does not affect the likelihood of an inefficient disclosure mandate.[16] This observation suggests that the novel disclosure mandate-induced investment inefficiency is driven by the imperfect credibility of disclosure due to a lack of certification.

Panel (b) of Figure 3 depicts the effect of V: for a given θ, we are more likely to observe the inefficient disclosure mandate when V is high than when it is low.[17] This is intuitive as a high V (i.e., high return from a successful risky project) increases the convexity of the manager's payoff and thus creates more distortion in risk taking.

3.3 Welfare Analysis

Section 3.3 examines welfare in each regulatory regime. Welfare is computed as the investment efficiency minus the expected certification cost, that is, the certification cost is assumed to be wasteful. For example, auditors must give up other careers to provide certification services, and firms must incur the costs of installing and operating an internal information system for finance and accounting purposes.[18] Proposition 2 summarizes the welfare results.

Proposition 2 (Welfare)**.** *The following statements regarding welfare are true.*

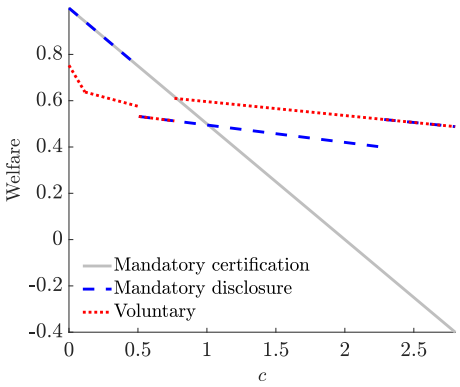
(1) *Welfare is highest in the mandatory certification and mandatory disclosure regimes if* $c \leq \underline{c}$.

(2) *Welfare in the voluntary regime is higher than that in the mandatory disclosure regime if* $\underline{c} < c < V - 1$.

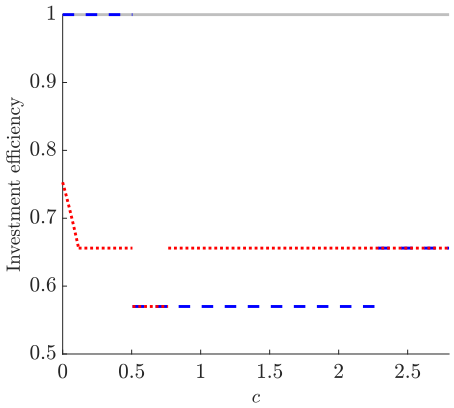
[16] When both θ and q are close to 1, the variation of q appears to affect the likelihood of observing an inefficient disclosure mandate. However, this effect arises simply because F does not choose the risk-free project in the voluntary regime (given the certification cost); thus, her project choice cannot worsen when we move from the voluntary regime to the mandatory disclosure regime.

[17] This result also rationalizes our focus on the interesting parameter region in which $V > \underline{V}$; see Section 2.

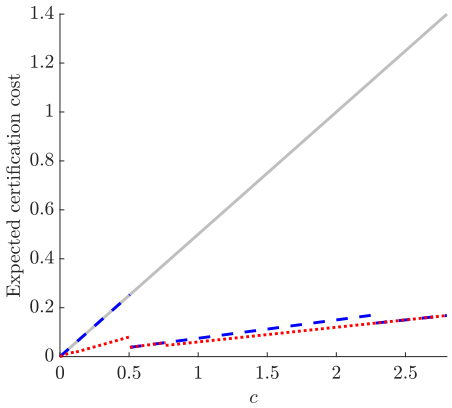
[18] If the certification cost is viewed as a transfer between firms and auditors, then welfare is equivalent to investment efficiency.



(a) Welfare



(b) Investment efficiency



(c) Expected certification cost

This figure plots welfare, expected investment efficiency, and expected certification costs within each regulatory regime in Panels (a)–(c), respectively. The parameters are: $p = 0.15, q = 0.5, \theta = 0.8$, and $V = 3.8$. The corresponding thresholds are: $\underline{\underline{c}}^V = 0.115, \underline{c} = 0.506, \bar{c}^V = 0.765$, and $\bar{c}^{MD} = 2.285$.

Figure 4: Welfare Analysis

The key driving force of welfare results is the trade-off between potentially greater investment efficiency and the increased probability of incurring certification costs in more (vs. less) regulated regimes. Intuitively, when the cost of certification is sufficiently low, investment efficiency is the dominant factor in determining social welfare. The mandatory disclosure regime, therefore, has a (weakly) lower welfare level than the mandatory certification regime due to its (weakly) lower investment efficiency. When the cost of certification is sufficiently high, this cost becomes the dominant factor in determining social welfare. The mandatory disclosure regime, therefore, has a (weakly) lower welfare level than the voluntary regime as the latter features

fewer disclosures than the mandatory regime and, therefore, provides fewer incentives for certification. When the certification cost is moderate, the mandatory disclosure regime could result in both lower investment efficiency and a higher certification cost than the voluntary regime. As a result, welfare levels are lower in the mandatory regime than in the voluntary regime. In other words, the mandatory disclosure regime never dominates both the mandatory certification and voluntary regimes in terms of social welfare.

As a useful complement to Proposition 2, we plot welfare in the three regulatory regimes in Panel (a) of Figure 4. To better illustrate the key trade-off, we also plot the expected investment efficiency and certification costs in Panels (b) and (c), respectively.[19]

Specifically, we obtain the following insights. First, Part (1) of Proposition 2 states that when the certification cost is low (i.e., $c \leq \underline{c} = 0.506$ in Figure 4), the two more regulated regimes – the mandatory certification and mandatory disclosure regimes – are equally associated with the highest levels of welfare. Intuitively, increased investment efficiency is sustained at the expense of the certification cost, and only for low certification costs can the improved investment efficiency outweigh the additional cost. Panels (b) and (c) of Figure 4 confirm that the high welfare levels in these two regulated regimes do indeed arise from their high levels of investment efficiency. Notably, in Panel (a), when the certification cost c exceeds $1/q$ (i.e., $c > 2$ in Figure 4), imposing the strictest regulations can be welfare destroying.

Second, for high certification costs (i.e., $c > \underline{c} = 0.506$ in Figure 4), welfare in the voluntary regime is (at least weakly) higher than that in the mandatory disclosure regime.[20] As shown in Panels (b) and (c) of Figure 4, the higher welfare levels featured in the voluntary regime are attributed to both the regime's higher investment efficiency and its lower expected certification costs relative to the mandatory disclosure regime. Moreover, as shown in Panel (a) of Figure 4, the voluntary regime can also feature higher welfare levels than the mandatory certification regime, making it the sole regime featuring the highest levels of welfare. This observation is unsurprising

[19]The choice of the parameters in Figure 4 is consistent with Assumption 1 and Figure 2. See the Supplementary Appendix (online) for other representative scenarios.

[20]In this paragraph, all "higher" and "lower" terms are in the weakly sense.

given that high certification costs can ultimately erode investment efficiency gains in this most regulated regime.

To summarize, we find that the mandatory disclosure regime can never be the sole regime that generates the highest levels of social welfare. This finding reinforces our main argument that mandating disclosure without mandating certification is undesirable, both in terms of investment efficiency and social welfare.

We conclude this section with a final remark. Panel (a) of Figure 4 shows that in both the mandatory disclosure and voluntary regimes, non-monotonic relations exist between welfare and certification costs; that is, very high or low certification costs lead to high welfare, whereas moderate certification costs lead to low welfare. As discussed previously, similar non-monotonic relations exist between investment efficiency and certification costs in these two regimes (also see Panel (b) of Figure 4). These results suggest that when certification is not mandatory, the regulator's intention to lower certification costs could have the unintended consequences of harming firms' investment efficiencies and social welfare.

4 Extensions

In this section, we explore several extensions to our baseline model and exhibit the robustness of our results. To save space, we briefly discuss these extensions and their implications, and refer interested readers to Sections OA3–OA5 in the Supplementary Appendix (online) for further details regarding each extension.

4.1 Misreporting by Uninformed S

In the baseline model, we assume that a manager can make a disclosure (truthful or not) only when she receives evidence. Under this assumption, the mandatory disclosure regime is an environment in which the regulator is aware of whether the manager has received information and can enforce disclosure or non-disclosure. Strictly speaking, such an assumption implicitly elicits

a *weak* form of certification.[21] We now relax this assumption by examining an extended setting in which even an uninformed S can make a cheap-talk type of disclosure. Thus, the extended model differs from the baseline model only in terms of the mandatory disclosure and voluntary regimes: in both regimes, upon receiving no evidence, F remains silent whereas S may misreport.

We find that the extended model exhibits the same equilibrium as the baseline model. That is, the ability of an uninformed S to misreport does not affect the equilibrium. In fact, in the baseline model, the price response to non-disclosure is always (weakly) higher than an uncertified report of 1. This is because non-disclosure can only come from an uninformed manager (regardless of her type) whereas an uncertified report of 1 might be issued by S upon project failure. This observation suggests that when S receives no evidence, her dominant strategy is to remain silent. Moreover, allowing S to falsely report 1 in the absence of evidence can only increase the price response to non-disclosure (i.e., when observing no disclosure, investors are more confident that the manager has not received any evidence) and simultaneously decrease the investors' price response to the uncertified report of 1. As such, any equilibrium involving an uninformed S misreporting with a positive probability should not be sustained, rendering the equilibrium in the extended model the same as that in the baseline model.

4.2 Auditor Market Power

In this section, we examine the effects of the auditing market structure on investment efficiency by considering a monopolistic certifier. At the beginning of this extended setting, a monopolistic certifier sets the certification fee to maximize the expected profit from the provision of the certification service,[22] given that the marginal cost of the certification service is c. The auditing

[21] The certification we refer to is a verification of actual quantitative evidence received by the manager. As a result, the manager must be truthful about the evidence once it is certified. This *strong* form of certification is an examination of both the existence and the content of the evidence. A weak form of certification refers to any qualitative check only on the existence of evidence. See Dye (2017) for scenarios that some fact finders enforce, albeit imperfectly, what is known as the "duty to disclose" requirement. When this weak form of certification is not feasible, the mandatory disclosure regime degenerates to the voluntary regime.

[22] A related paper by Marinovic and Sridhar (2015) solves the optimal disclosure strategy of a firm facing a strategic certifier that also sets the certification fee endogenously. The focus in their paper is on how the noise in certification affects firms' disclosure behavior in the absence of investment decisions.

market in the baseline model thus features a certification fee equal to the marginal certification cost, which occurs when the auditing market is perfectly competitive or when there are at least two certifiers competing on prices (a.k.a. Bertrand competition).

We find that the monopolistic certifier sets the certification fee above its marginal cost, extracting rents from the firm. However, despite the high certification fee, investment efficiency is not necessarily lower in the extended model than in the baseline model. The intuition hinges on the non-monotonic relations between a firm's investment efficiency and its certification costs, as discussed at the end of Section 3.3. A high certification fee induces F to adopt an investment and disclosure strategy free from any certification. As such, F may switch to the risk-free project for some levels of certification fees in the extended model, whereas both F and S choose the risky project for the corresponding marginal cost in the baseline model. As a result, the premium charged by the monopolistic certifier may actually help enhance investment efficiency.

4.3 Managers with Long-term Incentives

In the baseline model, the manager is fully myopic, concerned only with short-term stock prices. Our primary result that a disclosure mandate alone can lead to increased investment distortions robustly holds as long as the manager sufficiently cares about the short-term stock prices. This is intuitive, as a necessary condition for investment inefficiency is managerial myopia; the manager strategically manipulates the firm's cash flow and information flow to influence investor perception and the firm pricing, resulting in investment distortions. Moreover, we show numerically in the online appendix OA.5 that within the same regulatory regime, when the manager is sufficiently myopic (that is, when the concern with the long-term firm value is sufficiently low), the manager's increasing concern with the long-term firm value (from the sufficiently low level) leads to improved investment efficiency.

5 Conclusion and Discussion

We explore the real implications of certification, how such implications vary depending on whether certification is mandatory or voluntary, and how mandatory certification differs from mandatory disclosure. We conclude this study by discussing some empirical and policy implications.

First, we provide an alternative argument in favor of mandatory *certified* disclosure (i.e., to avoid investment distortions caused by managers' focus on short-term share prices). Specifically, in the voluntary certification regime, managers are willing to take on more risks than can be justified by the expected returns because riskier projects, if successful, have the potential to generate more impressive results. When these results are generated, managers can voluntarily choose to certify and report favorable outcomes to investors to increase short-term share prices. Mandatory certification removes such discretion and leads to efficient project selection. Furthermore, we demonstrate that mandatory disclosure without mandatory certification is not sufficient to restore investment efficiency and can even result in worse investment decisions relative to laissez-faire conditions. Indeed, forcing firms to disclose without imposing corresponding certification of the disclosure increases the misreporting of efficient project outcomes in situations wherein the inefficient project is selected and the evidence is unfavorable. The potential for misreporting reduces the price response to such uncertified reports and, consequently, the incentive of managers to select efficient projects. These results support the theory that mandatory certified financial reports improve investment efficiency, whereas mandatory disclosure (without mandatory certification) may unintentionally harm investment efficiency, even in the absence of any externalities.

Broadly speaking, this insight is also related to the relevance-reliability trade-off, a fundamental issue in accounting. We highlight the importance of the reliability criterion for financial reporting because if the information is not reliable, mandating disclosure under the premise of its relevance alone could result in inefficient investment and decreased social welfare. This insight is applicable to a variety of issues in accounting where the relevance-reliability trade-off is important (e.g., employee stock option disclosures, and pension disclosures).

A timely and relevant issue is environmental, social and governance (ESG) disclosure. The SEC has recently proposed rules to enhance climate-related disclosures including climate risk and carbon emissions (see, e.g., https://www.sec.gov/news/press-release/2022-46). However, measurement of carbon emissions, in particular, scope 3 emissions, is extremely difficult to verify. As a result, at least among S&P 500 companies, very few choose to certify such disclosures (see, e.g., https://www.thecaq.org/sp-500-and-esg-reporting/). Our paper would imply that the proposed policy of simply mandating ESG disclosure without mandating certification may result in inefficient investment in ESG activities and a lower social welfare than not mandating anything.

Second, we show that in the voluntary and mandatory disclosure regimes, investment efficiency is non-monotonic with respect to the certification cost. Specifically, when the certification cost is very high or low, investment efficiency is high. When the certification cost is moderate, as it increases from low to high, investment efficiency first decreases and then increases after the cost reaches a certain level. This phenomenon occurs when managers attempt to balance the increased likelihoods of certifying and reporting impressive results with decreased price responses to uncertified reports (truthful or not) and silence, while taking into account the *effective* certification cost.

Third, we show that in the mandatory disclosure and voluntary regimes, compared with a competitive auditing market, a monopolistic certifier charges higher certification fees. However, these higher fees do not necessarily lead to reduced investment efficiency. On the contrary, the monopolistic auditing market may be associated with higher investment efficiency under certain conditions, suggesting that introducing competition into the auditing market may not help improve real efficiency.

Finally, we posit that firms may take on inefficiently high levels of risk that can be justified by expected returns when certification is not mandatory. There may be other circumstances under which it is socially beneficial for firm managers to take on high risks (e.g., conducting innovative research, such as developing new cancer treatments), which may not generate the largest expected cash flows in the immediate future. Our results suggest that to encourage such

risk-taking behavior, it may be preferable to offer managers the option of issuing uncertified financial reports to firms operating in highly innovative industries (e.g., pharmaceuticals and artificial intelligence).[23]

[23]We thank Henry Friedman for this insight.

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Appendix: Proofs

Throughout the proof, let $X_\emptyset$ denote investors' belief about the firm value upon non-disclosure and $X_{n,NC}$ their belief about the firm value when the manager discloses n but does not certify the evidence. Note that any disclosure with certification is credible, so investors' expected firm value is equal to the certified disclosure; that is, $X_{n,C} = n$.

The proof of Lemma 1 is straightforward and is thus skipped.

Proof of Lemma 2

In the proof, we classify the equilibrium according to the manager's project choices. For each case, we first conjecture the possible equilibrium, and then derive the conditions that can sustain the conjectured equilibrium. Note that in this characterization process we assume investors' belief about the firm value to be 0 for any off-equilibrium path. This assumption assigns the most pessimistic beliefs to any deviations from the equilibrium (i.e., investors believe that these deviations are made by S who selects the risky project and observes 0) and thus helps generate all possible equilibria. When multiple equilibria exist, we select the equilibrium that is preferred by both types of managers (i.e., the sender's Pareto dominant equilibrium).

To simplify the subsequent analysis, we first make the following statements about the manager's disclosure/certification strategy in the mandatory disclosure regime.

- Statement 1: Either F or S must certify V. This is because (i) if otherwise the market believes the uncertified disclosure of V to be truthful, that is, $X_{V,NC} = V$, then S would always claim V regardless of the project outcome, which invalidates the initial belief that the uncertified disclosure of V is truthful; and (ii) the region of certification costs we focus on (i.e., $c < V - 1$) indeed makes it a dominant strategy for the manager to certify V.

- Statement 2: When choosing the risky project and observing 0, S is always weakly better off not to issue a report of 0 or an uncertified report V. This is because (i) 0 is the worst possible outcome and (ii) by Statement 1, V is always certified so that any uncertified disclosure of V results in the worst belief. As a result, neither 0 nor uncertified V is reported by S.

- Statement 3: F does not certify a report of 0.

1. Both F and S choose the risk-free project.

1.1. Suppose that both F and S disclose but do not certify the evidence 1. Given this conjecture, $X_{\emptyset} = X_{1,NC} = 1$, and $X_{0,NC} = X_{V,NC} = 0$.[24] It is easy to check that neither F nor S will deviate to certification since $X_{1,NC} > 1 - c$ for any $c > 0$. F will not deviate to the risky project and certify V (only) if $1 \geq p(V - c) + (1 - p)X_{0,NC}$, which yields $c \geq V - \frac{1}{p}$.[25] Similarly, S will not deviate to the risky project if $1 \geq p(V - c) + (1 - p)\, X_{1,NC}$, which yields $c \geq V - 1$. Taken together, the conjectured equilibrium can be sustained only when $c \geq V - 1$. Therefore, such a conjectured equilibrium does not exist for $c < V - 1$.

1.2. Suppose that both F and S disclose and certify the evidence 1. Under this conjecture, $X_{\emptyset} = 1$ and $X_{1,NC} = X_{0,NC} = X_{V,NC} = 0$. F will not deviate to no certification if $1 - c \geq X_{1,NC}$, which yields $c \leq 1$; nor will F deviate to the risky project if $1 - c \geq p(V - c) + (1 - p)X_{0,NC}$, which yields $c \leq \frac{1-pV}{1-p}$. Similarly, S will not deviate to no certification if $c \leq 1$, nor the risky project if $c \leq \frac{1-pV}{1-p}$. Since $\frac{1-pV}{1-p} < 1$, the conjectured equilibrium can be sustained when

$$c \leq \underline{c} \equiv \frac{1 - pV}{1 - p}. \tag{A1}$$

Note that $\underline{c} < V - 1$ for $V > \underline{V}$. In equilibrium, F and S have the same payoff:

$$\pi_F = \pi_S = 1 - qc. \tag{A2}$$

1.3. Suppose that both F and S disclose and adopt a mixed strategy in certification. Under this conjecture, $X_{\emptyset} = X_{1,NC} = 1$ and $X_{0,NC} = X_{V,NC} = 0$. Conditional on that a manager receives the evidence 1, if she certifies and discloses it, her payoff is $1 - c$, otherwise her payoff is $X_{\emptyset}$ or $X_{1,NC}$. The manager must be indifferent between these options in the mixed strategy equilibrium, namely, $X_{\emptyset} = 1 - c$, which can only hold if $c = 0$. But as argued in Cases 1.1 and 1.2, if $c = 0$, with $X_{1,NC} = 1$, the manager is always better off to deviate to the risky project and disclose and certify only V. So this conjectured equilibrium cannot be sustained.

2. F chooses the risk-free project and S randomizes between the risky and risk-free projects.

2.1. Suppose that S discloses and certifies the evidence of 1. To sustain S's mixed strategy, the following indifference condition must hold:[26] $1 - c = p(V - c) + (1 - p)X_{1,NC}$, which yields

[24] As we note in the beginning of the proof, $X_{0,NC} = X_{V,NC} = 0$ because when characterizing each type of equilibrium, for the off-equilibrium paths, we assume that the investors believe the firm value to be 0.

[25] Since investors hold the same belief about the firm value if the manager does not receive any evidence (and thus makes no disclosure), we only need to consider the case in which the manager receives evidence in examining her potential deviations.

[26] Note that in the mandatory disclosure regime, S has to disclose something if she invests in the risky project and observes 0. Since any uncertified disclosure prompts investors to infer that the firm value is 0, i.e., $X_{0,NC} = X_{1,NC} = X_{V,NC} = 0$, it does not matter whether the disclosure is specified to be 0, 1, or V.

$c = \frac{1-pV}{1-p}$. Since S certifies 1, F must certify 1 as well. For F to not deviate to the risky project, we need $1 - c \geq p(V - c) + (1 - p)X_{0,NC}$, which yields $c \leq \frac{1-pV}{1-p}$; for F to not deviate to not certify 1, we need $1 - c \geq X_{1,NC}$, which yields $c \leq 1$ (note that $\frac{1-pV}{1-p} < 1$). Therefore, the conjectured equilibrium can be sustained only when $c = \frac{1-pV}{1-p}$, which is a knife-edge case and we will simply assume it away.

2.2. Suppose that S discloses but does not certify the evidence of 1. If S does not certify 1, F will not certify 1 either. Otherwise if the two types of managers adopt different certification strategies, upon seeing a report of 1, investors can perfectly infer the manager type and assign a higher value to F as F makes the more efficient investment. Then it will be profitable for S to mimic F. The indifference condition for S requires the following: $X_{1,NC} = p(V - c) + (1 - p)X_{1,NC}$, which yields $X_{1,NC} = V - c$. As we focus on the region where $c < V - 1$, this suggests that $X_{1,NC} > 1$, which is impossible. Therefore, the conjectured equilibrium cannot be sustained.

3. F chooses the risk-free project and S chooses the risky project.

3.1. Suppose that F certifies the evidence of 1. Then, $X_{0,NC} = X_{1,NC} = 0$. For F not to deviate to the risky project, we need $1 - c \geq p(V - c) + (1 - p)X_{0,NC}$, which yields $c \leq \frac{1-pV}{1-p}$. For F not to deviate from certifying 1, we need $1 - c \geq X_{1,NC}$, or equivalently, $c \leq 1$, which must hold if $c \leq \frac{1-pV}{1-p}$. For S not to deviate to the risk-free project, we need $p(V - c) + (1 - p)X_{1,NC} \geq 1 - c$, which yields $c \geq \frac{1-pV}{1-p}$. Overall, the conjectured equilibrium can be sustained when $c = \frac{1-pV}{1-p}$; again, this is a knife-edge case and we simply assume it away.

3.2. Suppose that F does not certify the evidence of 1. Then S must report and certify V when she observes V and misreport (without certifying) 1 when she observes 0. Based on this conjecture, $X_{\emptyset} = 1 - \theta + \theta pV$, $X_{1,NC} = \frac{1-\theta}{1-\theta+\theta(1-p)} = \frac{1-\theta}{1-\theta p}$, and $X_{0,NC} = 0$. For F not to deviate to the risky project, we need $X_{1,NC} \geq p(V - c)$, which yields $c \geq V - \frac{1-\theta}{p(1-p\theta)}$, and for F not to deviate to certification, we need $X_{1,NC} \geq 1 - c$, which yields $c \geq 1 - \frac{1-\theta}{1-p\theta}$. When $V > \underline{V} \equiv \max\{\frac{1}{p} - \frac{\theta(1-p)^2}{p(1-p\theta)}, 2 - p\}$, the former inequality is sufficient for both inequalities to hold.

Further, for S not to deviate to the risk-free project, we need $p(V-c)+(1-p)X_{1,NC} \geq X_{1,NC}$, which yields $c \leq V - \frac{1-\theta}{1-\theta p}$. Overall, since $V - \frac{1-\theta}{1-\theta p} > V - 1$, the conjectured equilibrium can be sustained when

$$\bar{c}^{MD} \equiv V - \frac{1 - \theta}{p(1 - \theta p)} \leq c < V - 1. \tag{A3}$$

Finally, note that since $(V - 1) - \bar{c}^{MD} = \frac{(1-p)(1-\theta-p\theta)}{p(1-p\theta)} > 0$ if and only if $\theta(1 + p) < 1$. So, only when

$$\theta(1 + p) < 1, \tag{A4}$$

can the conjectured equilibrium be sustained. In equilibrium, the payoffs of F and S are:

$$\pi_F = (1-q)X_\emptyset + qX_{1,NC} \text{ and } \pi_S = (1-q)X_\emptyset + pq(V-c) + (1-p)qX_{1,NC}, \tag{A5}$$

which can be further simplified to the following: $\pi_F = (1-q)(1-\theta+\theta pV) + \frac{q(1-\theta)}{1-\theta p}$ and $\pi_S = (1-q)(1-\theta+\theta pV) + pq(V-c) + q(1-p)\frac{1-\theta}{1-\theta p}$.

4. Both F and S randomize between the two projects.

This equilibrium cannot be sustained because F likes the risky project less than S. So if S is indifferent between the two projects, F must prefer the risk-free project.

5. F randomizes between the two projects and S chooses the risky project.

5.1. Suppose that F certifies 1. Then, F's indifference condition is $1-c = p(V-c) + X_{0,NC}$, which yields $c = \frac{1-pV}{1-p}$. We also verify that for $c = \frac{1-pV}{1-p}$, S will not deviate to the risk-free project. Therefore, the conjectured equilibrium can be sustained when $c = \frac{1-pV}{1-p}$; again, this is a knife-edge case and we simply assume it away.

5.2. Suppose that F does not certify 1. Consider that F chooses the risk-free project with probability $\tau \in (0,1)$ and S misreports 1 without certifying it when observing 0. Then $X_{1,NC} = \frac{(1-\theta)\tau}{(1-\theta)\tau+\theta(1-p)}$ and $X_\emptyset = (1-\theta)(\tau+(1-\tau)pV) + \theta pV$. The indifference condition for F is

$$\begin{aligned} & X_{1,NC} = p(V-c) + (1-p)X_{0,NC} \Rightarrow X_{1,NC} = p(V-c) \\ \Rightarrow\ & \tau = \frac{(1-p)(V-c)p\theta}{(1-pV+pc)(1-\theta)}. \end{aligned} \tag{A6}$$

Obviously, $\tau > 0$, and only when $c > V - \frac{1-\theta}{p(1-p\theta)}$, $\tau < 1$. Moreover, we can show that when $c \geq \frac{1-pV}{1-p}$, F will not deviate to certifying 1 because $X_{1,NC} = p(V-c) \geq 1-c$, and S will not deviate to the risk-free project because $p(V-c) + (1-p)X_{1,NC} \geq X_{1,NC} \geq 1-c$.

Overall, the conjectured equilibrium can be sustained when

$$c > \bar{c}^{MD} \equiv V - \frac{1-\theta}{p(1-p\theta)} \text{ and } c \geq \underline{c} \equiv \frac{1-pV}{1-p}. \tag{A7}$$

In equilibrium, the payoffs of F and S are:

$$\pi_F = (1-q)X_\emptyset + q\tau X_{1,NC} + q(1-\tau)p(V-c) = (1-q)X_\emptyset + pq(V-c), \tag{A8}$$

$$\pi_S = (1-q)X_\emptyset + pq(V-c) + (1-p)qX_{1,NC}, \tag{A9}$$

which can be further simplifed to the following: $\pi_F = p\left(V + \frac{\theta(1-p)(1-q)(V-c)(1-pV)}{1-pV+pc} - qc\right)$ and $\pi_S = p\left(V + qV(1-p) + \frac{\theta(1-p)(1-q)(V-c)(1-pV)}{1-pV+pc} - qc(2-p)\right)$.

6. Both F and S choose the risky project.

We conjecture that both F and S disclose and certify V; F discloses but does not certify 0, whereas S may misreport evidence when observing 0 (note that S is indifferent between misreporting and truthful disclosure, since both result in the same investor belief of failed risky project). Then $X_{n,NC} = 0$, where $n \in \{0, V, 1\}$, and $X_\emptyset = pV$. For F not to deviate to the risk-free project, we need either 1) $p(V-c) + (1-p)X_{0,NC} \geq X_{1,NC}$ provided F does not certify 1, which must hold as $c < V - 1$; or 2) $p(V-c) + (1-p)X_{0,NC} \geq 1 - c$ provided F certifies 1, which yields $c \geq \frac{1-pV}{1-p}$. Similarly, we can verify that under the same conditions, S will not deviate to the risk-free project. Overall, the conjectured equilibrium can be sustained when

$$\underline{c} \equiv \frac{1-pV}{1-p} \leq c < V - 1. \tag{A10}$$

In this equilibrium, the payoffs of F and S are as follows (recall $X_{1,NC} = 0$):

$$\pi_F = \pi_S = (1-q)X_\emptyset + pq(V-c), \tag{A11}$$

which can be simplified as follows: $\pi_F = \pi_S = p(V - qc)$.

Equilibrium Selection Having characterized all possible equilibria for a given c, we now select an equilibrium when multiple equilibria coexist. We select the sender-preferred equilibrium, i.e., the one that is preferred by both types of managers.

First, when $c = \underline{c}$, the equilibria in Cases 1.2 and 6 coexist - note that we have assumed away the equilibria in Cases 2.1, 3.1 and 5.1 since they are knife-edge cases. Based on equations (A2) and (A11), we know that both F and S have higher payoffs in Case 1.2 since $1 - qc - p(V - qc) = (1-q)(1-pV) > 0$, where the equality follows by inserting $c = \underline{c}$. We thus select the equilibrium in Case 1.2.

Second, when $c = \bar{c}^{MD}$, the equilibria in Cases 3.2 and 6 coexist. Because Case 3.2 features higher investment efficiency, it is straightforward that $X_\emptyset^{\text{Case 3.2}} > X_\emptyset^{\text{Case 6}}$ (note that we use the superscript to differentiate $X_\emptyset$ in different cases). Then, by equations (A5) and (A11), $\pi_S^{\text{Case 3.2}} > \pi_S^{\text{Case 6}}$. By equations (A5) and (A11), since $X_{1,NC}^{\text{Case 3.2}} - p(V-c) = \frac{1-\theta}{1-\theta p} - p(V-c) \geq 0$ where the inequality holds because $c \geq \bar{c}^{MD}$, we obtain $\pi_F^{\text{Case 3.2}} > \pi_F^{\text{Case 6}}$. We thus select the equilibrium in Case 3.2.

Third, when $c > \bar{c}^{MD}$, the equilibria in cases 3.2, 5.2, and 6 coexist. We have shown that

the Case 3.2 equilibrium is associated with higher payoffs for both manager types than the Case 6 equilibrium, so we only need to compare Cases 3.2 and 5.2. Since the expected investment efficiency is higher in Case 3.2, we have $X_{\emptyset}^{\text{Case 3.2}} > X_{\emptyset}^{\text{Case 5.2}}$. Further, relative to Case 3.2, F chooses the risk-free project less likely in Case 5.2, which should lower the price response to the uncertified report of 1, that is, $X_{1,NC}^{\text{Case 3.2}} > X_{1,NC}^{\text{Case 5.2}}$. Taken together, by equations (A5) and (A9), we have $\pi_S^{\text{Case 3.2}} > \pi_S^{\text{Case 5.2}}$. Next we check F's payoffs across the two cases. It can be shown that $X_{1,NC}^{\text{Case 3.2}} - \left(q\tau X_{1,NC}^{\text{Case 5.2}} + q(1-\tau)p(V-c)\right) = \frac{1-\theta}{1-\theta p} - pq(V-c) \geq 0$, where the inequality holds because $c \geq \bar{c}^{MD}$. Combined with $X_{\emptyset}^{\text{Case 3.2}} > X_{\emptyset}^{\text{Case 5.2}}$, equations (A5) and (A8) guarantee $\pi_F^{\text{Case 3.2}} > \pi_F^{\text{Case 5.2}}$. Therefore, the equilibrium in Case 3.2 is associated with higher payoffs for both types of managers and is thus selected.

Proof of Lemma 3

The proof is similar to that of Lemma 2. We first conjecture the possible equilibrium and then solve for the conditions that can sustain the conjectured equilibrium. Finally, we select an equilibrium when there are multiple equilibria, based on the sender-preferred equilibrium criteria. Statements 1–3 continue to hold in the voluntary regime.

1. Both F and S choose the risk-free project.

1.1. Suppose F does not certify 1. Given this conjecture, we know that $X_{\emptyset} = X_{1,NC} = 1$ and $X_{0,NC} = 0$. It is easy to check that neither type deviates to certification as $X_{1,NC} > 1 - c$. F will not deviate to the risky project if $X_{1,NC} \geq p(V-c) + (1-p)X_{0,NC}$, which yields $c \geq V - \frac{1}{p}$. S will not deviate to the risky project if $X_{1,NC} \geq p(V-c) + (1-p)\,X_{\emptyset}$, which yields $c \geq V - 1$. However, as we focus on the region where $c < V - 1$, the conjectured equilibrium cannot be sustained.

1.2. Suppose F certifies 1. Under this conjecture, we know that $X_{\emptyset} = 1$, and $X_{n,NC} = 0$, where $n \in \{0, V, 1\}$. This cannot be sustained as an equilibrium because S will always deviate to the risky project: $1 - c < p(V-c) + (1-p)X_{\emptyset}$.

To sum up, the conjectured equilibrium in Case 1 can not be sustained.

2. F chooses the risk-free project and S randomizes between the two projects.

First, since S adopts a mixed strategy, she must certify the evidence when observing 1. Otherwise, S always finds it optimal to switch to the risky project from the risk-free one and misreports 1 without certification when she observes 0: $X_{1,NC} < p(V-c) + (1-p)X_{1,NC}$. This inequality holds because $X_{1,NC} \leq 1$ and we focus on the region where $c < V - 1$. Second, if S certifies 1, then F must also certify 1. If not, then S always finds it optimal to mimic F. Third, since F has chosen to certify 1, S cannot misreport 1 when observing 0.

Based on these observations, we have the following conjecture about the equilibrium. Suppose that F chooses the risk-free project, discloses and certifies whenever she has evidence 1; S randomizes between the risky and risk-free projects, discloses and certifies the evidence of 1 or V and withholds the evidence of 0. Let $\tau_S \in (0,1)$ be the probability of S choosing the risk-free project.

Given this conjecture, $X_{n,NC} = 0$ and $X_\emptyset = \frac{(1-q)(1-\theta+\theta(\tau_S+(1-\tau_S)pV))}{1-q+\theta(1-\tau_S)(1-p)q}$. For F not to deviate to the risky project, we need $1-c \geq p(V-c)+(1-p)X_{0,NC}$, which yields $c \leq \frac{1-pV}{1-p}$. The indifference condition for S is $1-c = p(V-c)+(1-p)X_\emptyset$, which yields $c = \frac{1-pV}{1-p} - X_\emptyset$. So the above two conditions are consistent. Further, based on the indifference condition, we have

$$\tau_S = 1 - \frac{(1-q)(c(1-p)+p(V-1))}{(1-p)\theta(1-qc(1-p)-pV)}. \tag{A12}$$

Note that $\frac{\partial \tau_S}{\partial c} = -\frac{(1-q)(1-pV-pq(V-1))}{\theta(1-qc(1-p)-pV)^2} < 0$; when $\tau_S = 1$, $c = -\frac{p(V-1)}{1-p} < 0$, and when $\tau_S = 0$, $c = \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)}$. Therefore, to ensure $\tau_S \in (0,1)$, we need $c < \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)}$. Taken together, the conjectured equilibrium can be sustained if

$$\begin{aligned} &\frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)} > 0 \\ \text{and } c < \underline{\underline{c}}^V &\equiv \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)}. \end{aligned} \tag{A13}$$

In equilibrium, F and S have the same payoff: $\pi_F = \pi_S = \frac{1-p(q+(1-q)V)}{1-p} - c$.

3. F chooses the risk-free project and S chooses the risky project.

3.1. Suppose that F certifies 1. Then S will not misreport 1 when observing 0, so S can only withhold information. Based on this conjecture, $X_\emptyset = \frac{(1-q)(1-\theta+\theta pV)}{1-q+\theta(1-p)q} < 1$ and $X_{n,NC} = 0$, where $n \in \{0,1,V\}$. For F not to deviate to the risky project, we need $1-c \geq p(V-c)+(1-p)X_{0,NC}$, which yields $c \leq \frac{1-pV}{1-p}$. It is obvious that for $0 < c \leq \frac{1-pV}{1-p}$, F will not deviate to non-certification as $1-c > X_{1,NC}$. S will not deviate to the risk-free project if $p(V-c)+(1-p)X_\emptyset \geq 1-c$, which yields $c \geq \frac{1-pV}{1-p} - X_\emptyset$. Therefore, the conjectured equilibrium can be sustained when

$$\underline{\underline{c}}^V \equiv \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)} \leq c \leq \underline{c} \equiv \frac{1-pV}{1-p}. \tag{A14}$$

In equilibrium, F and S have the payoff

$$\pi_F = (1-q)X_\emptyset + q(1-c), \tag{A15}$$

$$\pi_S = (1-pq)X_\emptyset + pq(V-c), \tag{A16}$$

which can be simplified as follows: $\pi_F = q(1-c) + \frac{(1-q)^2(1-\theta+\theta pV)}{1-q+\theta(1-p)q}$ and $\pi_S = pq(V-c) + \frac{(1-q)(1-pq)(1-\theta+\theta pV)}{1-q+\theta(1-p)q}$, respectively.

3.2. Suppose that F does not certify 1. First, we prove by contradiction that when receiving 0, S must mix between misreporting 1 without certification and withholding the evidence. Suppose not. Assume that S misreports 1 without certification when receiving 0. Then $X_\emptyset = 1-\theta+\theta pV$ and $X_{1,NC} = \frac{1-\theta}{1-\theta+\theta(1-p)}$. She will always find it optimal to deviate to withholding information because $X_\emptyset - X_{1,NC} = \frac{p\theta(V-1+(1-pV)\theta)}{1-p\theta} > 0$. Assume now that S withholds evidence when receiving 0. Then $X_{1,NC} = 1$ and $X_\emptyset < 1$. This means that S is better off by deviating to misreporting because $X_\emptyset < X_{1,NC}$. Taken together, S must adopt a mixed strategy between misreporting 1 without certification and withholding information when observing 0.

Assume S misreports 1 when observing 0 with a probability $\psi \in (0,1)$ and withholds the evidence with the complementary probability $1-\psi$. Under this conjecture, $X_{1,NC} = \frac{1-\theta}{1-\theta+\theta(1-p)\psi}$ and $X_\emptyset = \frac{(1-q)(1-\theta+\theta pV)}{1-q+\theta(1-p)q(1-\psi)}$. For S's mixed strategy to hold, we must have $X_{1,NC} = X_\emptyset$, which yields

$$\psi = \frac{(1-\theta)(1-pq-(1-q)pV)}{(1-p)\left(1-\theta+\theta(1-q)pV\right)}. \tag{A17}$$

We now verify that $\psi \in (0,1)$. Because $1-pq-(1-q)pV > 1-pqV-(1-q)pV = 1-pV > 0$, we have $\psi > 0$. Since $(1-\theta)(1-pq-(1-q)pV) - (1-p)\left(1-\theta+\theta(1-q)pV\right) = p(1-q)\left(1-V-\theta(1-pV)\right) < 0$, we have $\psi < 1$.

To sustain the equilibrium, for F not to deviate to the risky project, we need $X_{1,NC} \geq p(V-c)+(1-p)X_{0,NC}$, which yields $c \geq V - \frac{1}{p}\frac{1-\theta}{1-\theta(1-\psi(1-p))}$. For F and S not to deviate to certification if the risk-free project is selected, we need $X_{1,NC} \geq 1-c$, which yields $c \geq \frac{(1-p)\theta\psi}{1-\theta(1-\psi(1-p))}$. Further, $V-c > 1 > X_{1,NC} = X_\emptyset$ ensures that S will not deviate to the risk-free project.

Therefore, the conjectured equilibrium can be sustained when

$$c \geq \bar{c}^V \equiv \max\{V - \frac{1}{p}\frac{1-\theta}{1-\theta(1-\psi(1-p))}, \frac{(1-p)\theta\psi}{1-\theta(1-\psi(1-p))}\}. \tag{A18}$$

In equilibrium, the payoffs of F and S are (note that $X_{1,NC} = X_\emptyset$):

$$\pi_F = (1-q)X_\emptyset + qX_\emptyset, \tag{A19}$$

$$\pi_S = (1-pq)X_\emptyset + pq(V-c), \tag{A20}$$

which can be simplified as follows: $\pi_F = \frac{1-\theta+pV\theta(1-q)}{1-pq\theta}$ and $\pi_S = \frac{1-\theta+pq(V-1-c)+p\theta(V-q((1+p)V-1)+pq^2c)}{1-pq\theta}$.

4. Both F and S randomize between the two projects.

For the same reason as in Case 4 of the proof of Lemma 2, this conjectured equilibrium cannot be sustained in this regime.

5. F randomizes between the two projects and S chooses the risky project.

Suppose that F certifies 1. Then F's indifference condition is $1-c = p(V-c)+(1-p)X_{0,NC}$, which yields $c = \frac{1-pV}{1-p}$. As discussed previously, we assume away this knife-edge case. So we only consider the case where F does not certify 1. Assume F chooses the risk-free project with probability $\tau \in (0,1)$.

5.1. Suppose that S stays silent when observing 0. Then $X_{1,NC} = 1$ and $X_\emptyset = \frac{(1-q)((1-\theta)(\tau+(1-\tau)pV)+\theta pV)}{1-q+\theta(1-p)q}$. However, this conjectured equilibrium cannot be sustained because S will deviate to misreporting 1 without certification: $X_\emptyset < (1-\theta)(\tau+(1-\tau)pV)+\theta pV < X_{1,NC}$.

5.2. Suppose that S misreports 1 when observing 0. Then $X_{1,NC} = \frac{(1-\theta)\tau}{(1-\theta)\tau+\theta(1-p)}$ and $X_\emptyset = (1-\theta)(\tau+(1-\tau)pV)+\theta pV$. The indifference condition for F is

$$X_{1,NC} = p(V-c)+(1-p)X_{0,NC} \Rightarrow p(V-c) = \frac{(1-\theta)\tau}{(1-\theta)\tau+\theta(1-p)}$$
$$\Rightarrow \tau = \frac{(1-p)(V-c)p\theta}{(1-pV+pc)(1-\theta)}.$$

It is easy to check that when $c \le V - \frac{1-\theta}{p(1-p\theta)}$, $\tau \ge 1$. So one necessary condition for this conjectured equilibrium to arise is that $c > \bar{c}^{MD} \equiv V - \frac{1-\theta}{p(1-p\theta)}$. Next we show that the conjectured equilibrium cannot be sustained because $X_\emptyset > X_{1,NC}$, which is inconsistent with the conjecture that S misreports 1 when observing 0. Specifically, inserting τ, we can compute that $X_\emptyset = p\left(V(1+\theta(1-p)) - c\frac{(1-p)\theta}{1+cp-pV}\right) > p\left(V - c\frac{(1-p)\theta}{1+cp-pV}\right) > p(V-c) = X_{1,NC}$, where the first inequality holds because $1+\theta(1-p) > 1$ and the second inequality holds because when $c > \bar{c}^{MD}$, $\frac{(1-p)\theta}{1+cp-pV} < 1-p\theta < 1$.

5.3. Suppose that S randomizes between misreporting and withholding information when observ-

ing 0. Assume that S misreports 1 when observing 0 with probability of $\psi' \in (0,1)$. Therefore,

$$X_{1,NC} = \frac{(1-\theta)\tau}{(1-\theta)\tau + \theta(1-p)\psi'},$$
$$X_{\emptyset} = \frac{(1-q)\left((1-\theta)(\tau + (1-\tau)pV) + \theta pV\right)}{1-q+\theta(1-p)q(1-\psi')}.$$

The indifference condition for F is

$$X_{1,NC} = p(V-c) + (1-p)X_{0,NC} \Rightarrow X_{1,NC} = p(V-c)$$
$$\Rightarrow \tau = \frac{p\theta\psi'(1-p)(V-c)}{(1-\theta)(1-p(V-c))}. \tag{A21}$$

Based on equation (A21), τ is positively related to ψ'. Since Case 3.2 is the extreme case where $\tau = 1$, we have $\psi > \psi'$, where ψ is given by (A17). Thus, relative to Case 3.2, the investment efficiency is lower in this conjectured equilibrium; coupled with the fact that when observing 0, S stays silent more likely (i.e., $1-\psi' > 1-\psi$), the price response to non-disclosure is lower in this conjectured equilibrium, that is, $X_{\emptyset}^{\text{Case 3.2}} > X_{\emptyset}^{\text{Case 5.3}}$ (we use the superscript to denote different cases). Since $X_{\emptyset}^{\text{Case 3.2}} = X_{1,NC}^{\text{Case 3.2}}$ and $X_{\emptyset}^{\text{Case 5.3}} = X_{1,NC}^{\text{Case 5.3}}$, we have $X_{1,NC}^{\text{Case 3.2}} > X_{1,NC}^{\text{Case 5.3}}$. In this conjectured equilibrium in Case 5.3, for F and S not to deviate to certification, we need $c \geq 1 - X_{1,NC}^{\text{Case 5.3}} > 1 - X_{1,NC}^{\text{Case 3.2}}$, where the second inequality follows from $X_{1,NC}^{\text{Case 3.2}} > X_{1,NC}^{\text{Case 5.3}}$. Therefore, the condition to sustain the conjectured equilibrium in Case 5.3 must be a subset of the condition that sustains the equilibrium in Case 3.2. In other words, the equilibrium in Case 5.3, if exists, must coexist with the equilibrium in Case 3.2. We next show that the equilibrium in Case 3.2 is always preferred by both types of managers, and thus we do not need to further consider Case 5.3.

In the equilibrium of Case 5.3, F and S have the following payoff:

$$\pi_F = (1-q)X_{\emptyset} + q\tau X_{1,NC} + q(1-\tau)p(V-c) = (1-q)X_{\emptyset} + qX_{1,NC}, \tag{A22}$$

$$\pi_S = (1-pq)X_{\emptyset} + pq(V-c). \tag{A23}$$

Due to the fact that $X_{1,NC}^{\text{Case 3.2}} = X_{\emptyset}^{\text{Case 3.2}} > X_{1,NC}^{\text{Case 5.3}} = X_{\emptyset}^{\text{Case 5.3}}$, we have $\pi_F^{\text{Case 3.2}} > \pi_F^{\text{Case 5.3}}$ by equations (A19) and (A22), and $\pi_S^{\text{Case 3.2}} > \pi_S^{\text{Case 5.3}}$ by equations (A20) and (A23). Therefore, the equilibrium in Case 3.2 features higher payoffs for both types of managers.

6. Both F and S choose the risky project.

Suppose that both F and S disclose and certify V; F discloses but does not certify 0, whereas S

withholds information when observing 0. Then $X_{0,NC} = X_{1,NC} = 0$, and $X_\emptyset = \frac{(1-q)pV}{1-q+\theta(1-p)q}$. For F not to deviate to the risk-free project we need

$$p(V-c) + (1-p)X_{0,NC} \geq X_{1,NC} \Rightarrow c \leq V,$$
$$\text{and } p(V-c) + (1-p)X_{0,NC} \geq 1-c \Rightarrow c \geq \frac{1-pV}{1-p}.$$

For S not to deviate to the risk-free project we need

$$p(V-c) + (1-p)X_\emptyset \geq X_{1,NC} \Rightarrow c \leq V + \left(\frac{1}{p} - 1\right) X_\emptyset,$$
$$\text{and } p(V-c) + (1-p)X_\emptyset \geq 1-c \Rightarrow c \geq \frac{1-pV-X_\emptyset}{1-p}.$$

As we focus on the region $c < V - 1$, the condition to sustain the conjectured equilibrium boils down to

$$\underline{c} \equiv \frac{1-pV}{1-p} \leq c < V - 1. \tag{A24}$$

In equilibrium, F and S have the following payoffs:

$$\pi_F = (1-q)X_\emptyset + pq(V-c), \tag{A25}$$
$$\pi_S = (1-pq)X_\emptyset + pq(V-c), \tag{A26}$$

which can be simplified as follows: $\pi_F = pq(V-c) + (1-q)\frac{(1-q)pV}{1-q+\theta(1-p)q}$ and $\pi_S = (1-pq)\frac{(1-q)pV}{1-q+\theta(1-p)q} + pq(V-c)$.

Equilibrium Selection We make equilibrium selection in the presence of multiple equilibria. When $c \geq \bar{c}^V$, the equilibrium in Case 3.2 may respectively coexist with the equilibria in Cases 3.1 and 6. We next show that the equilibrium in Case 3.2 is always preferred by both types of managers. First, we compare Cases 3.1 and 3.2. Since the investment efficiency is the same across the two cases but when observing 0, S is less likely to choose to be silent in Case 3.2, the price response to non-disclosure must be higher in Case 3.2, that is, $X_\emptyset^{\text{Case 3.2}} > X_\emptyset^{\text{Case 3.1}}$. Then, by equations (A16) and (A20), we know that $\pi_S^{\text{Case 3.2}} > \pi_S^{\text{Case 3.1}}$. Further, in Case 3.2, we know that $X_{1,NC}^{\text{Case 3.2}} \geq 1 - c$ (for F and S not to deviate to certification); by equations (A15) and (A19), we

know that $\pi_F^{\text{Case 3.2}} > \pi_F^{\text{Case 3.1}}$. Therefore, both types of managers prefer the equilibrium in Case 3.2 to that in Case 3.1.

Second, we compare Cases 3.2 and 6. Since in Case 3.2 the investment efficiency is higher, and when observing 0, S stays silent less likely, the price response to non-disclosure is higher in Case 3.2, that is, $X_{\emptyset}^{\text{Case 3.2}} > X_{\emptyset}^{\text{Case 6}}$. By equations (A20) and (A26), we know that $\pi_S^{\text{Case 3.2}} > \pi_S^{\text{Case 6}}$. Moreover, since in Case 3.2, $X_{1,NC}^{\text{Case 3.2}} \geq p(V-c)$ (for F not to deviate to the risky project), by equations (A19) and (A25), we know that $\pi_F^{\text{Case 3.2}} > \pi_F^{\text{Case 6}}$. Therefore, both types of managers prefer the equilibrium in Case 3.2 to that in Case 6.

Proof of Proposition 1

The proof of Proposition 1 is based on Lemmas 1, 2, and 3 directly. Note that under the assumption $V > \underline{V}$, we must have $\underline{c} < \min\{\bar{c}^{MD}, V-1\}$ in the mandatory disclosure regime. Further, some regions in Cases (1)–(3) may be empty depending on the parameters. We plot in the main text a scenario in which all cases are nonempty but relegate other representative equilibrium patterns to Section OA2 in the Supplementary Appendix (Online).

Proof of Proposition 2

Based on Lemmas 1, 2 and 3, the expected certification costs incurred in the mandatory certification regime C_{MC}, in the mandatory disclosure regime C_{MD}, and in the voluntary regime C_V, are as follows, respectively:

$$C_{MC} = qc,\ C_{MD} = \begin{cases} qc & \text{if } c \leq \underline{c}, \\ pqc & \text{if } \underline{c} < c < \bar{c}^{MD}, \\ \theta pqc & \text{if } \bar{c}^{MD} \leq c < V-1, \end{cases} \tag{A27}$$

and

$$C_V = \begin{cases} (1-\theta)qc + \theta qc\left(\tau_S + (1-\tau_S)p\right) & \text{if } c < \underline{\underline{c}}^V, \\ (1-\theta)qc + \theta pqc & \text{if } \underline{\underline{c}}^V \leq c \leq \underline{c}, \\ pqc & \text{if } \underline{c} < c < \bar{c}^V, \\ \theta pqc & \text{if } \bar{c}^V \leq c < V-1, \end{cases} \tag{A28}$$

Welfare is the investment efficiency minus the expected certification cost. We can obtain that the welfare in the mandatory certification regime Ψ_{MC}, in the mandatory disclosure regime Ψ_{MD}, and in the voluntary regime Ψ_V, are as follows, respectively:

$$\Psi_{MC} = 1 - qc,\ \Psi_{MD} = \begin{cases} 1 - qc & \text{if } c \leq \underline{c}, \\ p(V - qc) & \text{if } \underline{c} < c < \bar{c}^{MD}, \\ 1 - \theta + \theta p(V - qc) & \text{if } \bar{c}^{MD} \leq c < V - 1, \end{cases} \tag{A29}$$

and

$$\Psi_V = \begin{cases} \frac{1-pq-pV(1-q)}{1-p} - c & \text{if } c < \underline{\underline{c}}^V, \\ (1-\theta)(1-qc) + \theta p(V - qc) & \text{if } \underline{\underline{c}}^V \leq c \leq \underline{c}, \\ p(V - qc) & \text{if } \underline{c} < c < \bar{c}^V, \\ 1 - \theta + \theta p(V - qc) & \text{if } \bar{c}^V \leq c < V - 1. \end{cases} \tag{A30}$$

We next compare welfare across regions.

First, when $c \leq \underline{c}$, based on (A29) and (A30) we know that $\Psi_{MC} = \Psi_{MD} > \Psi_V$, where the inequality follows because for 1) $c < \underline{\underline{c}}^V$,

$$\begin{aligned} (1 - qc) - \Big((1-\theta)(1-qc) + \theta\left(\tau_S(1-qc) + (1-\tau_S)p(V-qc)\right)\Big) \\ = \theta(1-\tau_S)\left(1 - pV - qc(1-p)\right) > \theta(1-q)(1-pV) > 0 \end{aligned}$$

and for 2) $\underline{\underline{c}}^V \leq c \leq \underline{c}$,

$$(1 - qc) - \Big((1-\theta)(1-qc) + \theta p(V-qc)\Big) = \theta(1 - pV - (1-p)qc) \geq \theta(1-q)(1-pV) > 0.$$

Second, we show that if $\underline{c} < c < V - 1$, the welfare in the voluntary regime is no lower than that in the mandatory disclosure regime, that is, $\Psi_V \geq \Psi_{MD}$. Based on (A29) and (A30), it is straightforward that if $\underline{c} < c < \bar{c}^V$ or $\bar{c}^{MD} \leq c < V - 1$, $\Psi_{MD} = \Psi_V$. Further, if $\bar{c}^V \leq c < \bar{c}^{MD}$, $\Psi_V > \Psi_{MD}$ because

$$\Psi_V - \Psi_{MD} = \Big(1 - \theta + \theta p(V - qc)\Big) - p(V - qc) = (1-\theta)(1 - pV + pqc) > 0.$$

Online Appendix

OA1 Mandatory Certification but Voluntary Disclosure

Consider another interim regime in which certification is mandatory whereas disclosure is voluntary. Specifically, F has no other options but has to always disclose and certify all received evidence; S can choose whether or not to disclose, but upon disclosure, the evidence must be certified. All other model setups are developed in the same way as in the main model. The following lemma summarizes the equilibrium in this interim regime.

Lemma OA1. *Let* $\underline{\underline{c}}^V \equiv \frac{1-pV}{1-p} - \frac{(1-q)(1-\theta+\theta pV)}{1-q+q\theta(1-p)}$. *Under mandatory certification but voluntary disclosure, F always selects the risk-free project and discloses and certifies the received evidence. The equilibrium project choice and disclosure and certification decisions of S are as follows.*

(1) *When* $c \leq \underline{\underline{c}}^V$, *S randomizes between the risk-free and risky projects, discloses and certifies the evidence when observing* 1 *or* V, *and withholds evidence when observing* 0. *This equilibrium mimics that in Case (1) of Lemma 3.*

(2) *When* $c > \underline{\underline{c}}^V$, *S chooses the risky project, discloses and certifies the evidence when observing* V *and withholds evidence when observing* 0. *The equilibrium mimics that in Case (2.1) of Lemma 3.*

Then, we can compare this regime with the other three regulatory regimes. The implications for investment efficiency are summarized as follows.

1. Relative to the voluntary regime, this regime is always associated with (weakly) higher investment efficiency. So, unlike the disclosure mandate, the certification mandate will not do harm. In other words, from the voluntary regime, to this regime, and to the most regulated regime, the investment efficiency always monotonically increases.

2. Relative to the mandatory disclosure regime, when $c > \underline{c}$, this regime has higher investment efficiency, whereas when $c \leq \underline{c}$, this regime has lower investment efficiency. Therefore, the disclosure mandate is more effective when the certification cost is low whereas the certification mandate is more effective when the certification cost is high.

Proof of Lemma OA1

We first observe the following facts in this regime to simplify the subsequent analysis.

(a) F must always choose the risk-free project. This is because for F both certification and disclosure become mandatory and her best response is simply to choose the project that maximizes the expected cash flow.

(b) $X_{n,NC} = 0$, where $n \in \{1, 0, V\}$.

(c) If S chooses the risky project, when observing 0 she must withhold the evidence, and when observing V she must disclose and certify the evidence.

As usual, we discuss based on the investment decisions made by the two types of managers when characterizing the equilibrium in this regime.

1. Both F and S choose the risk-free project.

Given the conjectured equilibrium, $X_\emptyset = 1$. Then, for S, when receiving evidence, she must withhold because $X_\emptyset \geq 1 - c$. However, S always has incentives to deviate to the risky project because $X_\emptyset < p(V - c) + (1 - p)X_\emptyset$. Therefore, the conjectured equilibrium cannot exist.

2. F chooses the risk-free project and S randomizes between the risky and risk-free projects.

First, suppose that S discloses and certifies evidence 1. Following the same procedure in Case 2 of proof of Lemma 3, we can solve that the conjectured equilibrium can be sustained if $c < \underline{\underline{c}}^V$, where $\underline{\underline{c}}^V$ is given by (A13). In equilibrium, F and S have the same payoff: $\pi_F = \pi_S = \frac{1-p(q+(1-q)V)}{1-p} - c$.

Second, suppose that S withholds evidence 1. Then for S to be indifferent between the two projects, it must be $X_\emptyset = p(V-c)+(1-p)X_\emptyset$, which must not hold since $X_\emptyset < 1$ and $c < V - 1$. Therefore, S must not withhold evidence 1.

3. F chooses the risk-free project and S chooses the risky project.

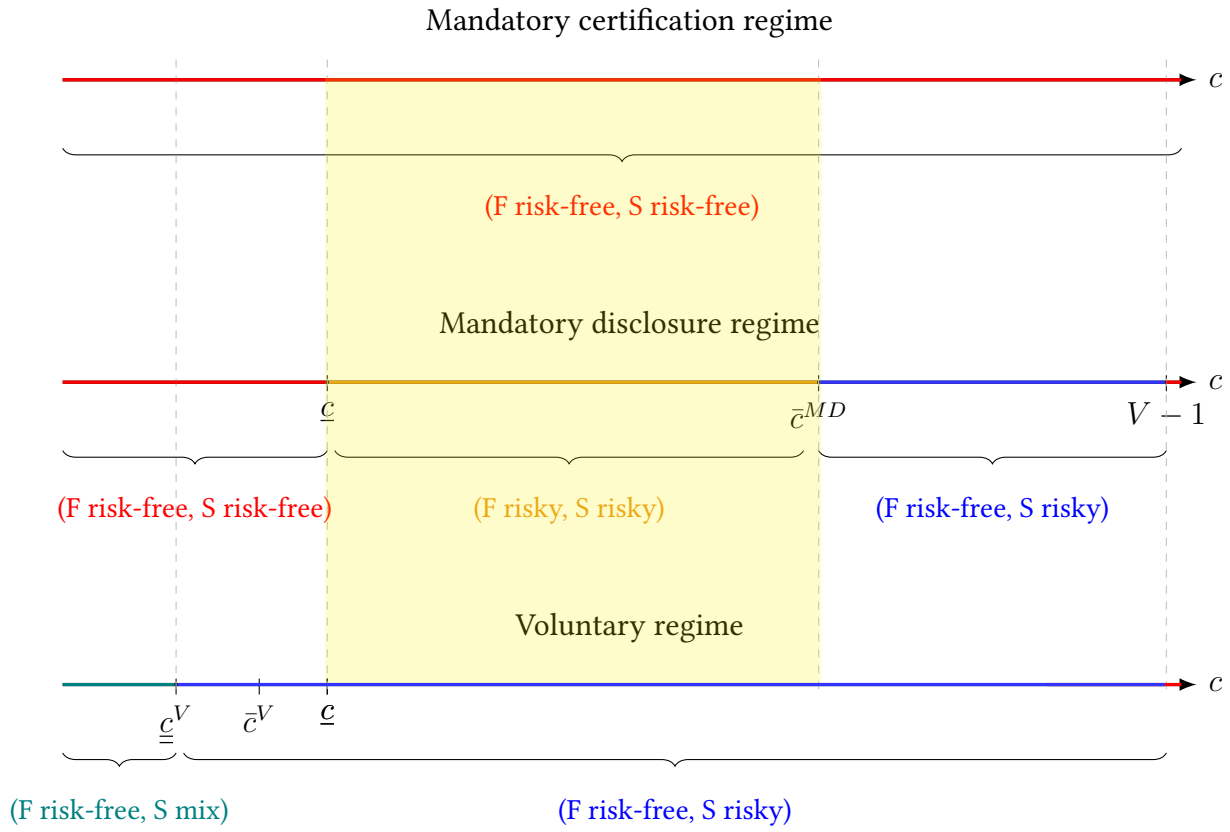
Following the same procedure as in the proof of Case 3.1 of Lemma 3, we can solve that the conjectured equilibrium can be sustained if $c \geq \underline{\underline{c}}^V$. In equilibrium, $\pi_F = q(1-c)+\frac{(1-q)^2(1-\theta+\theta pV)}{1-q+\theta(1-p)q}$ and $\pi_S = pq(V - c) + \frac{(1-q)(1-pq)(1-\theta+\theta pV)}{1-q+\theta(1-p)q}$.

OA2 Other Representative Scenarios

OA2.1 Investment Efficiency Comparison

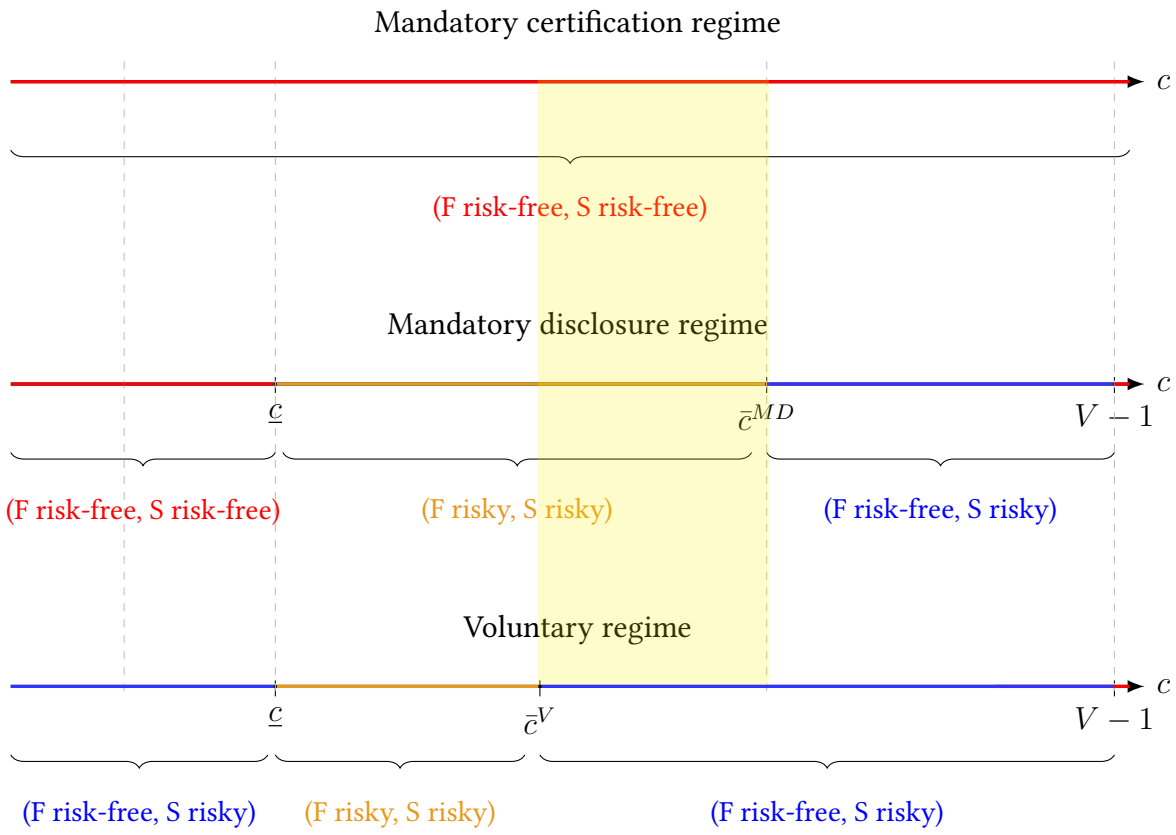
Recall that in Proposition 1 and Figure 2, we impose Assumption 1 so that all types of equilibria characterized in Lemmas 1–3 can arise. There are other scenarios (in violation of Assumption 1) that make some of the identified equilibria irrelevant - the parameter sets in support of such equilibria are empty. We now plot these other representative equilibrium patterns to demonstrate

the robustness of our key result (i.e., mandatory disclosure without mandatory certification can lead to lower investment efficiency than mandating neither).



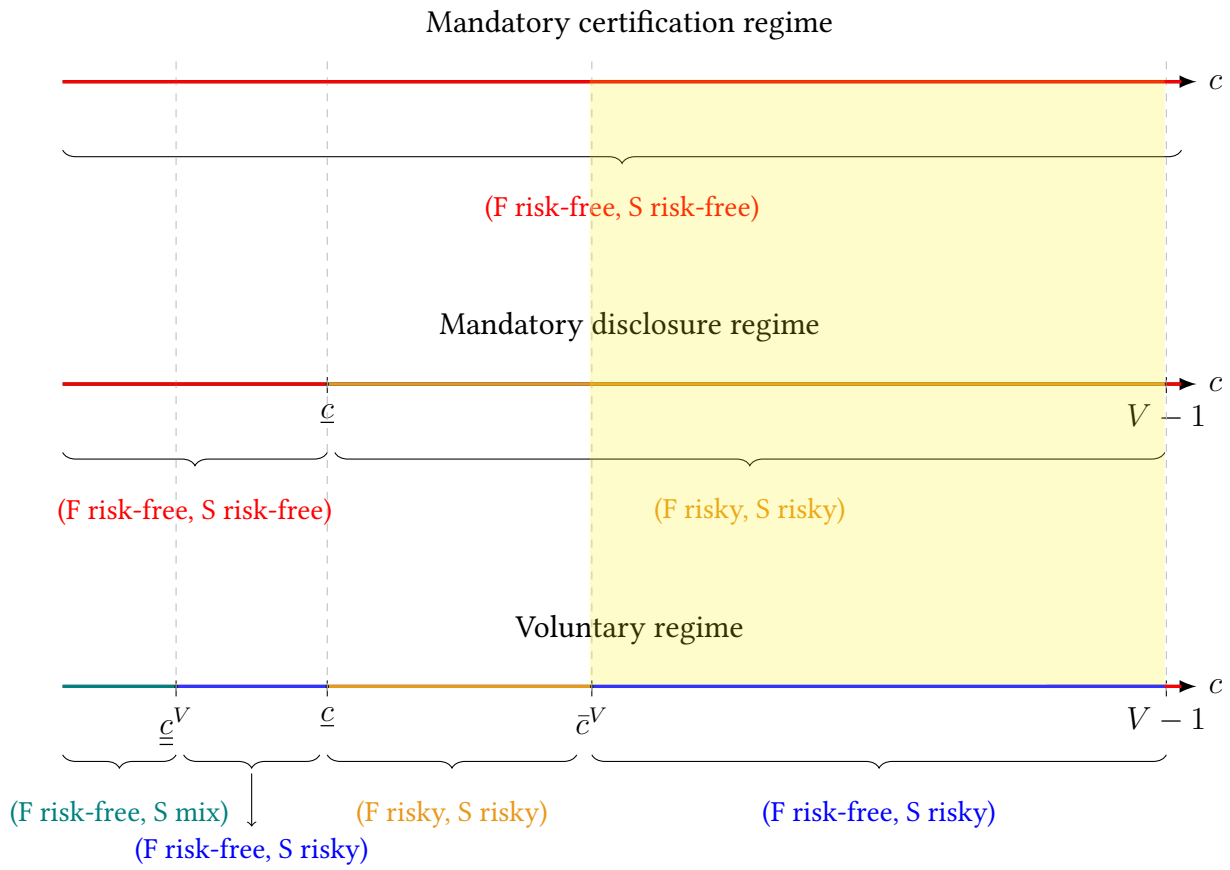
This figure plots the equilibrium project choices in the mandatory certification regime, the mandatory disclosure regime, and the voluntary regime. The shaded area plots the region in which the voluntary regime dominates the mandatory disclosure regime in terms of investment efficiency. The parameters are $p = 0.15, q = 0.5, \theta = 0.8$, and $V = 2.5$ such that $0 < \underline{\underline{c}}^{V} < \bar{c}^{V} < \bar{c} < \bar{c}^{MD} < V - 1$. This figure differs from Figure 2 only in that V is relatively low so that $\bar{c}^{V} < \underline{c}$.

Figure OA1: Comparison of investment efficiency across different regimes when $\bar{c}^{V} < \underline{c}$



This figure plots the equilibrium project choices in the mandatory certification regime, the mandatory disclosure regime, and the voluntary regime. The shaded area plots the region in which the voluntary regime dominates the mandatory disclosure regime in terms of investment efficiency. The parameters are $p = 0.15, q = 0.5, \theta = 0.8$, and $V = 6$ such that $\underline{\underline{c}}^V < 0 < \underline{c} < \bar{c}^V < \bar{c}^{MD} < V - 1$. This figure differs from Figure 2 only in that V is sufficiently high so that $\underline{\underline{c}}^V < 0$.

Figure OA2: Comparison of investment efficiency across different regimes when $\underline{\underline{c}}^V < 0$



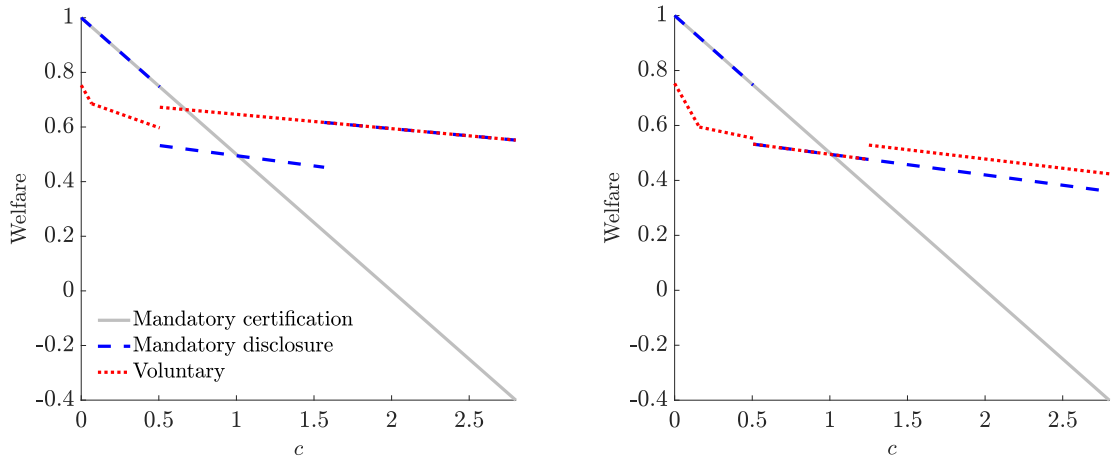
This figure plots the equilibrium project choices in the mandatory certification regime, the mandatory disclosure regime, and the voluntary regime. The shaded area plots the region in which the voluntary regime dominates the mandatory disclosure regime in terms of investment efficiency. The parameters are $p = 0.15, q = 0.5, \theta = 0.9$, and $V = 3.8$ such that $0 < \underline{\underline{c}}^V < \bar{c}^V < \bar{c} < V - 1 < \bar{c}^{MD}$. This figure differs from Figure 2 only in that θ is sufficiently high so that $\bar{c}^{MD} > V - 1$.

Figure OA3: Comparison of investment efficiency across different regimes when $\bar{c}^{MD} > V - 1$

It is straightforward that our key insight that mandating disclosure alone without mandating certification can adversely affect investment efficiency holds in all these other representative scenarios.

OA2.2 Welfare Analysis

Similarly, in the main analysis, we plot Figure 4 using parameters that are consistent with Assumption 1 (i.e., same as in Figure 2). In this section, we plot Figure OA4 to illustrate the robustness of our main welfare result (i.e., the mandatory disclosure regime can never be the sole regime that generates the highest social welfare) to parameters that do not conform to Assumption 1.



(a) $\theta = 0.7$ (b) $\theta = 0.9$

This figure plots welfare of each regulatory regime for different values of θ. The other parameters are: $p = 0.15, q = 0.5$, and $V = 3.8$.

Figure OA4: Welfare Analysis

OA3 Extension: Misreporting by Uninformed S

In this section, we investigate an extension in which an uninformed S has the ability to make a disclosure. Compared with the benchmark model, the extension differs only in the mandatory disclosure and voluntary regimes: upon receiving no evidence, F remains silent, whereas S may misreport, in both regimes. The following proposition summarizes the equilibrium in this extended setting.

Proposition OA1 (Misreporting by uninformed S)**.** *When S can misreport upon no evidence, the equilibria in the three regulatory regimes in the extended setting are the same as they are in the baseline economy.*

Proposition OA1 states that the extended model exhibits the same equilibrium as in the baseline model. As analyzed in Section 4.1, since the price response to non-disclosure is always (weakly) higher than an uncertified report of 1, when receiving no evidence, remaining silent is the dominant strategy for S. Therefore, allowing S to misreport without evidence does not change the equilibrium.

Proof of Proposition OA1

Since the mandatory certification regime in the extended economy is the same as that in the baseline model, their equilibria must be identical. We then focus on the equilibrium characterization in the other two regimes.

Mandatory disclosure regime

The proof for the mandatory disclosure regime in this section is closely related to that of Lemma 2. Relative to the mandatory disclosure regime of the baseline model, the extended economy differs in that S can misreport upon no evidence. Statements 1–3 in the proof of Lemma 2 remain valid in this extended economy. In addition, we make the following statements about S's disclosure/certification strategy upon no evidence in the extended economy, which help simplify the subsequent analysis.

- Statement 1': S must not certify her disclosure (if any) upon no evidence.
- Statement 2': S will not report 0 or V upon no evidence. This is because (i) 0 is the worst outcome, and (ii) while V is the best outcome, the low certification cost we focus on (i.e., $c < V - 1$) always makes it profitable to certify V and thus an uncertified report of V is priced at 0 by investors.
- Statement 3': S adopts the same disclosure and certification strategy upon receiving no evidence, regardless of her preceding investment decision. This is because regardless of whether the risky or risk-free project is selected, when no evidence is received, the same disclosure strategies by S must yield the same payoff, and thus S must always choose the most profitable strategy.
- Statement 4': In the mandatory disclosure regime, if in equilibrium F makes a more efficient investment than S, S will not adopt a pure strategy of misreporting 1 upon receiving no evidence. This is because according to Statement 3', if S always misreports 1 upon no evidence, then investors can make perfect inference that a non-disclosure is by F and price non-disclosure accordingly, which provides S an incentive to mimic F upon no evidence.

In the following equilibrium characterization, we first investigate if the equilibrium characterized in the proof of Lemma 2 can continue to hold in the extended economy by examining if $X_{\emptyset} \geq X_{1,NC}$. We then examine if any equilibrium involving S misreporting 1 upon no evidence can be sustained. We use 1' through 6' to represent each case here to differentiate from the corresponding cases in the proof of Lemma 2.

1'. Both F and S choose the risk-free project.

First, the equilibrium in Case 1.2 in the proof of Lemma 2 continues to hold in the extended economy under the same condition (A1) because in equilibrium $X_\emptyset > X_{n,NC}$ where $n \in \{0, V, 1\}$, that is, silence is indeed the dominant strategy for S upon no evidence.

Second, suppose that S misreports 1 upon no evidence. Under this conjectured equilibrium, neither F nor S should certify evidence 1. Then, $X_\emptyset = X_{1,NC} = 1$ and $X_{0,NC} = X_{V,NC} = 0$. However, as discussed in Case 1.1 of the proof of Lemma 2, this conjectured equilibrium cannot hold for $c < V - 1$. Similarly, we can show that S randomizing between misreporting 1 and staying silent upon no evidence cannot be sustained in equilibrium either.

2'. F chooses the risk-free project and S randomizes between the two projects.

Case 2 in the proof of Lemma 2 has shown that no equilibrium involving non-disclosure upon no evidence can be sustained. Now, suppose that S randomizes between misreporting 1 and staying silent upon no evidence. Under this conjecture, neither F nor S should certify 1. For S to be indifferent between the two projects, as discussed in Case 2.2 in the proof of Lemma 2, we need $X_{1,NC} = V - c$. However, as argued there, this condition cannot hold when $c < V - 1$. Therefore, the conjectured equilibrium cannot hold in the extended economy.

3'. F chooses the risk-free project and S chooses the risky projects.

First, the equilibrium in Case 3.2 in the proof of Lemma 2 continues to hold in the extended economy because in equilibrium $X_\emptyset - X_{1,NC} = (1 - \theta - \theta pV) - \frac{1-\theta}{1-\theta p} = \frac{\theta p[(V-1)+\theta(1-pV)]}{1-\theta p} > 0$. The equilibrium can be sustained under the same condition (A3).

Second, suppose that upon no evidence, S randomizes between misreport of 1 and silence and stays silent with probability $\eta \in (0, 1)$. Then, $X_{1,NC} = \frac{(1-\theta)q+\theta(1-q)\eta pV}{(1-\theta)q+\theta(1-q)\eta+\theta(1-p)q}$ and $X_\emptyset = \frac{(1-\theta)(1-q)+\theta(1-q)(1-\eta)pV}{(1-\theta)(1-q)+\theta(1-q)(1-\eta)}$. The indifference condition for S implies that $X_{1,NC} = X_\emptyset$, which yields $\eta = \frac{pq(1-\theta-(1-p\theta)V)}{(1-\theta)(1-pV)-(1-p)q\theta pV}$. Now, for F not to deviate to the risky project, we need $X_{1,NC} \geq p(V - c) + (1 - p)X_{0,NC}$, which yields $c \geq \frac{V(1-p\theta)-(1-\theta)}{1-pq\theta}$; and for S not to deviate to the risk-free project we need $p(V - c) + (1 - p)X_{1,NC} \geq X_{1,NC}$, which yields $c \leq \frac{V(1-p\theta)-(1-\theta)}{1-pq\theta}$. Therefore, the conjectured equilibrium only exists for $c = \frac{V(1-p\theta)-(1-\theta)}{1-pq\theta}$, which is at most a knife-edge case, and we assume it away.

4'. Both F and S randomize between the two projects.

For the same reason as in Case 4 of the proof of Lemma 2, this conjectured equilibrium cannot be sustained in this extended economy.

5'. F randomizes between the two projects and S chooses the risky project.

First, the equilibrium in Case 5.2 in the proof of Lemma 2 continues to hold in the extended economy. This is because with the calculated mixed strategy τ, we can compute that in equilibrium $X_\emptyset = p\left(V(1 + \theta - p\theta) - \frac{(1-p)\theta c}{1-p(V-c)}\right) > p(V(1 + \theta - p\theta) - (1 - p\theta)c) > p(V - c) = X_{1,NC}$,

where the first inequality follows by $c > V - \frac{1-\theta}{p(1-p\theta)}$ in (A7). The equilibrium can be sustained under the same condition as in (A7).

Second, suppose that upon no evidence S randomizes between misreport of 1 and silence. Denote τ' the probability of F choosing the risk-free project and $\eta \in (0,1)$ the probability of S staying silent upon no evidence. Then, again, F must not certify 1. Under these conjectures, we can compute that $X_{1,NC} = \frac{(1-\theta)\tau' q + \theta(1-q)(1-\eta)pV}{(1-\theta)\tau' q + \theta(1-q)p(1-\eta) + \theta(1-p)(1-\eta(1-q))}$ and $X_\emptyset = (1-\theta)(\tau' + (1-\tau')pV) + \theta\eta pV$. For F to be indifferent between the two projects we need $X_{1,NC} = p(V-c)$, which yields $\tau'(\eta) = \frac{p\theta((1-p)qV - c(1+q\eta-pq-\eta))}{q(1-\theta)(1+pc-pV)}$. Since $\frac{\partial \tau'(\eta)}{\partial \eta} > 0$ and $\tau'(1) = \tau$, where τ is given by (A6) in Case 5.2 of the proof of Lemma 2, we know that relative to the equilibrium in which S remains silent upon no evidence, the investment efficiency is lower when S randomizes between misreporting 1 and silence upon no evidence, that is, $\tau' < \tau$. This suggests that the price responses to non-disclosure and to the uncertified report of 1 are higher when S stays silent upon no evidence. Thus both managers should have higher payoffs when S stays silent upon no evidence. Moreover, this conjectured equilibrium can be sustained only if condition (A7) holds, which overlaps with the condition for the equilibrium in which S remains silent upon no evidence. Therefore, this conjectured equilibrium will not be selected.

6'. Both F and S choose the risky project.

First, the equilibrium in Case 6 in the proof of Lemma 2 continues to hold in the extended economy since $X_\emptyset > X_{n,NC}$, and the condition to sustain the equilibrium is the same as in (A10).

Second, upon no evidence, (i) S misreporting 1 or (ii) S randomizing between misreporting 1 and remaining silent cannot be sustained in equilibrium because under the conjectured equilibrium, silence is always the dominant strategy upon no evidence, that is, $X_\emptyset > X_{n,NC} = 0$.

To sum up, all equilibria that can be sustained in the proof of Lemma 2 continue to hold in the extended economy. And any equilibrium involving S misreporting 1 upon no evidence is either unsustained or dominated. In other words, the equilibria in the mandatory disclosure regime of the extended economy are identical to those in the mandatory disclosure regime of the baseline model.

Voluntary regime

The proof follows a similar procedure as in the mandatory disclosure regime above, and is closely related to that of Lemma 3. Statements 1–3 in the proof of Lemma 2 and Statements 1'–3' in the above section continue to be valid in this setting. In addition, we make an additional statement for the voluntary regime in the extended economy as follows.

- Statement 5': In the voluntary regime of the extended economy, in equilibrium S must adopt the same disclosure strategy upon observing no evidence and the evidence of 0. This

is because when receiving no evidence or observing 0, S is faced with the same strategy set and the same corresponding payoff (either staying silent or misreporting 1) and thus must take the same optimal action at each decision node.

1'. Both F and S choose the risk-free project.

Case 1 in the proof of Lemma 3 has shown that the equilibrium involving no disclosure upon no evidence cannot be sustained. Now, suppose that S misreports 1 upon no evidence. Then, neither F nor S certifies 1 and we know that $X_\emptyset = X_{1,NC} = 1$ and $X_{0,NC} = 0$. Following the same discussion as in Case 1.1, such an equilibrium cannot be sustained when $c < V - 1$. Similarly, S randomizing between misreporting 1 and staying silent cannot be sustained in equilibrium either.

2'. F chooses the risk-free project and S randomizes between the two projects.

First, the equilibrium characterized in Case 2 in the proof of Lemma 3 continues to hold in the extended economy as in equilibrium $X_\emptyset = \frac{1-pV}{1-p} - c \geq X_{1,NC} = 0$. The condition that sustains the equilibrium is the same as in (A13).

Second, suppose that S misreports 1 upon no evidence. Then, neither F nor S certifies a report of 1 (otherwise misreporting 1 is dominated by silence). However, if a report of 1 is not certified, as argued in the beginning of Case 2 in the proof of Lemma 3, S must deviate to the risky project. Similarly, it cannot hold that S adopts a mixed strategy between misreporting 1 and staying silent upon no evidence. Taken together, the equilibrium involving S misreporting 1 upon no evidence cannot be sustained.

3'. F chooses the risk-free project and S chooses the risky project.

First, both equilibria in Case 3.1 and Case 3.2 in the proof of Lemma 3 continue to hold in the extended economy as in equilibrium $X_\emptyset \geq X_{1,NC}$, and the respective conditions that sustain them are given by (A14) and (A18) respectively. In fact, in the equilibrium in Case 3.2, S randomizes between misreporting 1 and remaining silent upon no evidence as $X_\emptyset = X_{1,NC}$.

Second, suppose that S misreports 1 upon no evidence. Then, F must not certify the report of 1, and S must misreport 1 when observing 0 (by Statement 5'). However, this means that investors can perfectly infer that a non-disclosure is by F and set $X_\emptyset = 1$, which makes it profitable for S to deviate to silence. Therefore, the conjectured equilibrium cannot hold.

4'. Both F and S randomize between the two projects.

For the same reason as in Case 4 of the proof of Lemma 2, this conjectured equilibrium cannot be sustained in this extended economy.

5'. F randomizes between the two projects and S chooses the risky project.

First, the Case 5.2 equilibrium in the proof of Lemma 3 continues to hold in the extended economy: In equilibrium, we can compute that $X_{1,NC} = p(V - c)$, $X_\emptyset = p(V(1 + \theta - p\theta) -$

$\frac{(1-p)\theta c}{1-p(V-c)}$) and when $c > V - \frac{1-\theta}{p(1-p\theta)}$, $X_\emptyset > X_{1,NC}$. The necessary condition that sustains the equilibrium is $c > V - \frac{1-\theta}{p(1-p\theta)}$.

Second, suppose that S misreports 1 upon no evidence. Again, F must not certify the report of 1. Also, S must withhold information when observing 0 (otherwise, investors can perfectly infer F upon no disclosure and price silence accordingly. Then S has incentives to deviate to silence). Given these conjectures, $X_{1,NC} = \frac{(1-\theta)q\tau+\theta(1-q)pV}{(1-\theta)q\tau+\theta(1-q)}$. For F to be indifferent between the two projects, we need $X_{1,NC} = p(V-c)$, which yields $\tau = -\frac{p\theta(1-q)c}{q(1-\theta)(1-pV+pc)} < 0$. Therefore, the conjectured equilibrium cannot hold.

Third, suppose that S randomizes between misreporting 1 and staying silent. Then, S must also randomize between misreporting 1 and staying silent when observing 0. Denote $\tau' \in (0,1)$ the probability of F choosing the risk-free project, $\eta \in (0,1)$ the probability of S choosing to stay silent upon no evidence, and $\psi \in (0,1)$ the probability of misreporting 1 when observing 0. Under these conjectures, we can compute that $X_{1,NC} = \frac{(1-\theta)\tau' q+\theta(1-q)p(1-\eta)V}{(1-\theta)\tau' q+\theta(1-q)p(1-\eta)+\theta(1-p)(q\psi+(1-q)(1-\eta))}$ and $X_\emptyset = \frac{(1-\theta)(1-q)(\tau'+(1-\tau')pV)+\theta(1-q)\eta pV}{(1-\theta)(1-q)+\theta(1-q)p\eta+\theta(1-p)(q(1-\psi)+(1-q)\eta)}$. For F to be indifferent between the two projects, we need $X_{1,NC} = p(V-c)$, which yields $\tau'(\eta) = \frac{p\theta(c(1-\eta)-(1-p)\psi qV-qc(1-\eta-\psi+p\psi))}{q(1-\theta)(1+pc-pV)}$. Since $\frac{\partial\tau'(\eta)}{\partial\eta} > 0$ and $\tau'(1) = \tau$, where τ is given by (A21) in Case 5.3 in the proof of Lemma 3, we know that relative to the equilibrium in which S remains silent upon no evidence, the investment efficiency is lower when S randomizes between misreporting 1 and staying silent, that is, $\tau' < \tau$. Moreover, since allowing S to falsely misreport upon no evidence can only reduce the price responses to non-disclosure and to the uncertified report of 1, the payoffs of both F and S must be reduced, and thus this conjectured equilibrium will not be selected.

6'. Both F and S choose the risky project.

First, the equilibrium in Case 6 in the proof of Lemma 3 continues to hold in the extended economy as $X_\emptyset > X_{1,NC}$ under the same condition (A24).

Second, upon no evidence, any equilibrium involving (i) S misreporting 1, or (ii) S randomizing between misreporting 1 and staying silent cannot be sustained. This is because in the conjectured equilibrium, any uncertified report of 1 is along the off-equilibrium path and leads to the worst investor inference (and thus the lowest manager payoff).

To sum up, all equilibria that can be sustained in the proof of Lemma 3 continue to hold in the extended economy. Furthermore, any equilibrium involving S misreporting 1 upon no evidence is either unsustained or dominated. In other words, the equilibria in the voluntary regime of the extended economy are identical to those in the voluntary regime of the baseline model.

OA4 Extension: Monopolistic Auditing Market

In this section, we examine the effects of the auditing market structure on investment efficiency by considering a monopolistic certifier. Specifically, the game in the extended setting begins with a monopolistic certifier setting the certification fee f to maximize the expected profit from the provision of the certification service. To make a fair comparison with the baseline model, the marginal cost of the monopolistic certifier to provide certification is assumed to be c, which suggests that $f \geq c$. Under this assumption, the auditing market in the baseline model features a certification fee equal to the marginal certification cost (i.e., $f = c$).

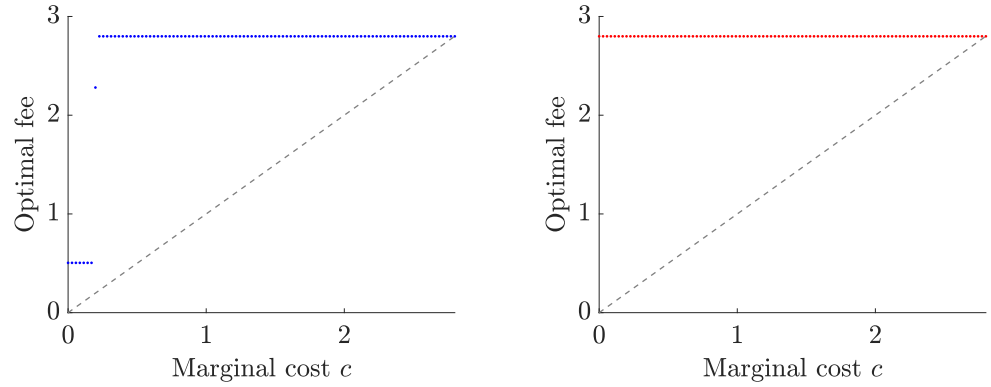
We present a graphical illustration of the effects of the auditing market structure on investment efficiency in Figure OA5 (the detailed derivation can be found under the paragraph starting with "The optimal certification fee set by the monopolistic certifier" at the end of this section). The insights from the baseline model remain robust for a wide range of parameter values in the extension. First, Panel (a) of Figure OA5 plots the optimal fee set by the monopolistic certifier in the mandatory disclosure and voluntary regimes.[27] The 45-degree line represents both the marginal cost faced by the monopolistic certifier and the certification cost in the baseline model. We find that consistent with our intuition, the monopolistic certifier sets the certification fee above its marginal cost, extracting rents from the firm.

Second, in Panel (b) of Figure OA5, we plot investment efficiency under the optimal monopolistic certification fee f^* in the mandatory disclosure and voluntary regimes (marked by blue "."). Investment efficiency under the corresponding marginal cost in the baseline model is presented as benchmarks (marked by red "+"). We find that despite the high certification fees charged by the monopolist, investment efficiency is not necessarily lower in the extended model, under both regulatory regimes. The intuition of this finding hinges on the non-monotonic relations between investment efficiency and the certification cost faced by the firm, as discussed in Section 3.3. A high certification fee induces F to adopt an investment and disclosure strategy free from any certification. As such, F may switch to the risk-free project for some levels of certification fees in the extended economy, whereas both F and S choose the risky project for the corresponding marginal cost in the baseline economy. As a result, the premium charged by the monopolistic certifier may improve investment efficiency.

The optimal certification fee set by the monopolistic certifier In the mandatory certification regime, given the inelastic demand for its certification service, the profit-maximizing certifier would charge an exorbitantly high certification fee to extract the maximum surplus, that is,

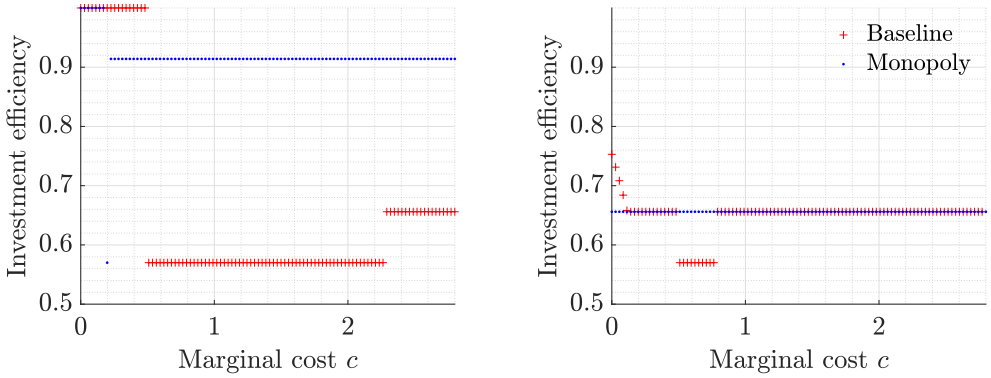
[27] If certification is mandated, given the inelastic demand for certification, a monopolistic certifier can charge an exorbitantly high certification fee and extract the entire surplus, which makes our analysis irrelevant. We therefore focus exclusively on the mandatory disclosure and voluntary regimes.

(a) Optimal fee



(a1) Mandatory disclosure regime (a2) Voluntary regime

(b) Investment efficiency



(b1) Mandatory disclosure regime (b2) Voluntary regime

Panel (a) of this figure plots the optimal certification fee set by the monopolistic certifier in the mandatory disclosure and voluntary regimes (marked by dots). Panel (b) contrasts the investment efficiency in the baseline economy where $f = c$ ("Baseline") to the investment efficiency in the extended economy where f is set optimally by the monopolistic certifier at $f^*(c)$ ("Monopoly"). The parameters are: $p = 0.15, q = 0.5, \theta = 0.8$, and $V = 3.8$.

Figure OA5: Effect of auditing market structure

$f^* \to \infty$. We thus only focus on the optimal certification fee and its implications for investment efficiency in the mandatory disclosure and voluntary regimes.

Based on (A27) and (A28) in the proof of Proposition 2, the monopolistic certifier's expected profit functions for a given marginal cost c in the mandatory disclosure and voluntary regimes

are respectively as follows:

$$\Pi_{MD}(f) = \begin{cases} q(f-c) & \text{if } f \leq \underline{c}, \\ pq(f-c) & \text{if } \underline{c} < f < \bar{c}^{MD}, \\ \theta pq(f-c) & \text{if } \bar{c}^{MD} \leq f < V-1, \end{cases}$$

$$\Pi_V(f) = \begin{cases} q\frac{1-(1-p)f+p(1-q)-pV(2-q)}{1-pV-qf(1-p)}(f-c) & \text{if } f < \underline{\underline{c}}^V, \\ \left((1-\theta)q+\theta pq\right)(f-c) & \text{if } \underline{\underline{c}}^V \leq f \leq \underline{c}, \\ pq(f-c) & \text{if } \underline{c} < f < \bar{c}^V, \\ \theta pq(f-c) & \text{if } \bar{c}^V \leq f < V-1, \end{cases}$$

We first discuss the determination of the optimal certification fee f^*_{MD} in the mandatory disclosure regime. We observe that the sub-profit-function in each region is increasing in f and thus the local maximum profit lies at the right edge of each region of f. Note that strictly speaking, in the regions $(\underline{c}, \bar{c}^{MD})$ and $[\bar{c}^{MD}, V-1)$, the locally optimal certification fees are respectively $\bar{c}^{MD} - \varepsilon$ and $V - 1 - \varepsilon$, where $\varepsilon > 0$ is close to zero. To simplify analysis and exposition, we treat all sub-sets right-closed. As such, to determine the global maximum profit, we only need to compare the three local maximum profits; that is, the global maximum profit for the certifier is $\Pi^*_{MD} = \max\{\Pi_{MD}(\underline{c}), \Pi_{MD}(\bar{c}^{MD}), \Pi_{MD}(V-1)\}$. Therefore, the optimal certification fee is $f^*_{MD} = \Pi^{-1}_{MD}(\Pi^*_{MD})$, and the corresponding investment efficiency is obtained accordingly based on Lemma 2.

Similarly, in the voluntary regime, we first identify the local maximum profit in each region of f and then find the global profit maximum point among them. Denote $\tilde{\Pi}_V$ the local maximum profit in the region $(0, \underline{\underline{c}}^V)$. In all other regions, the local maximum profits occur at the right edges of the corresponding regions, and thus the global maximum profit for the certifier is $\Pi^*_V = \max\{\tilde{\Pi}_V, \Pi_V(\underline{c}), \Pi_V(\bar{c}^V), \Pi_V(V-1)\}$. As in the mandatory disclosure regime, the optimal certification fee in the voluntary regime is $f^*_V = \Pi^{-1}_V(\Pi^*_V)$. We can then determine the corresponding investment efficiency based on Lemma 3.

OA5 Extension: Managers with Long-term Incentives

In the baseline model, we assume that the manager is fully myopic, concerned with the short-term stock price only. In this section, we relax this assumption by allowing a fraction $\alpha \in [0, 1]$ of the manager's payoff to depend on the firm selling price at $t = 2$, whereas the remaining fraction

$1-\alpha$ on the long-term firm value at $t=3$. As in the baseline model, we focus on the region with a relatively low certification cost such that not all three regulatory regimes are associated with the highest investment efficiency:

$$c < \bar{\bar{\kappa}} \equiv \frac{V}{q} - \frac{\alpha p(q+(1-q)V)+(1-\alpha)}{pq}.$$

All other model setups develop in the same way as in the baseline model. The baseline model is nested by assuming $\alpha = 1$.

Define

$$\begin{aligned}
&\underline{\kappa} \equiv \frac{(1-pV)(1-(1-q)\alpha)}{(1-p)q},\\
&\bar{\kappa}^{MD} \equiv \frac{(p(1-\alpha)+q\alpha-p^2V(1-(1-q)\alpha))\theta-(1-pV)(1-(1-q)\alpha)}{pq(1-p\theta)},\\
&\underline{\bar{\kappa}}^{V} \equiv \underline{\kappa} - \frac{(1-q)\alpha(1-(1-pV)\theta)}{1-q+(1-p)q\theta},\\
&\bar{\kappa}^{V} \equiv \max\{\frac{V}{q} - \frac{\begin{pmatrix} 1-(1-pV)\alpha-pq\theta-(1-p)q^2pV\alpha\theta \\ +q\alpha(1-pV)(1-(1-p)\theta) \end{pmatrix}}{pq(1-pq\theta)}, \frac{\theta\,(1-pV+pq(V-1))}{1-pq\theta}\}.
\end{aligned}$$

The following proposition summarizes the equilibria in the extended economy where the manager has long-term incentives when α is sufficiently close to 1. The proof is similar to those of Lemmas 1, 2, and 3 and is thus skipped.

Proposition OA2. *When α is sufficiently high (i.e., close to 1), the equilibria in the extended economy are as follows.*

(1) *In the mandatory certification regime, there is a unique equilibrium in which both F and S select the first-best risk-free project, and disclose and certify the received evidence of* 1.

(2) *In the mandatory disclosure regime,*

(2.1) *When $c \le \underline{\kappa}$, both F and S select the first-best risk-free project, and disclose and certify the received evidence of* 1*;*

(2.2) *When $\underline{\kappa} < c < \bar{\kappa}^{MD}$, both F and S select the risky project, disclose and certify the received evidence of V, but only disclose the received evidence of 0 without certification;*

(2.3) *When $\bar{\kappa}^{MD} \leq c < \bar{\bar{\kappa}}$, F selects the first-best risk-free project, discloses the received evidence of 1 without certification; S selects the risky project, discloses and certifies the received evidence of V, but misreports 1 without certification when receiving evidence of 0.*

(3) *In the voluntary regime,*

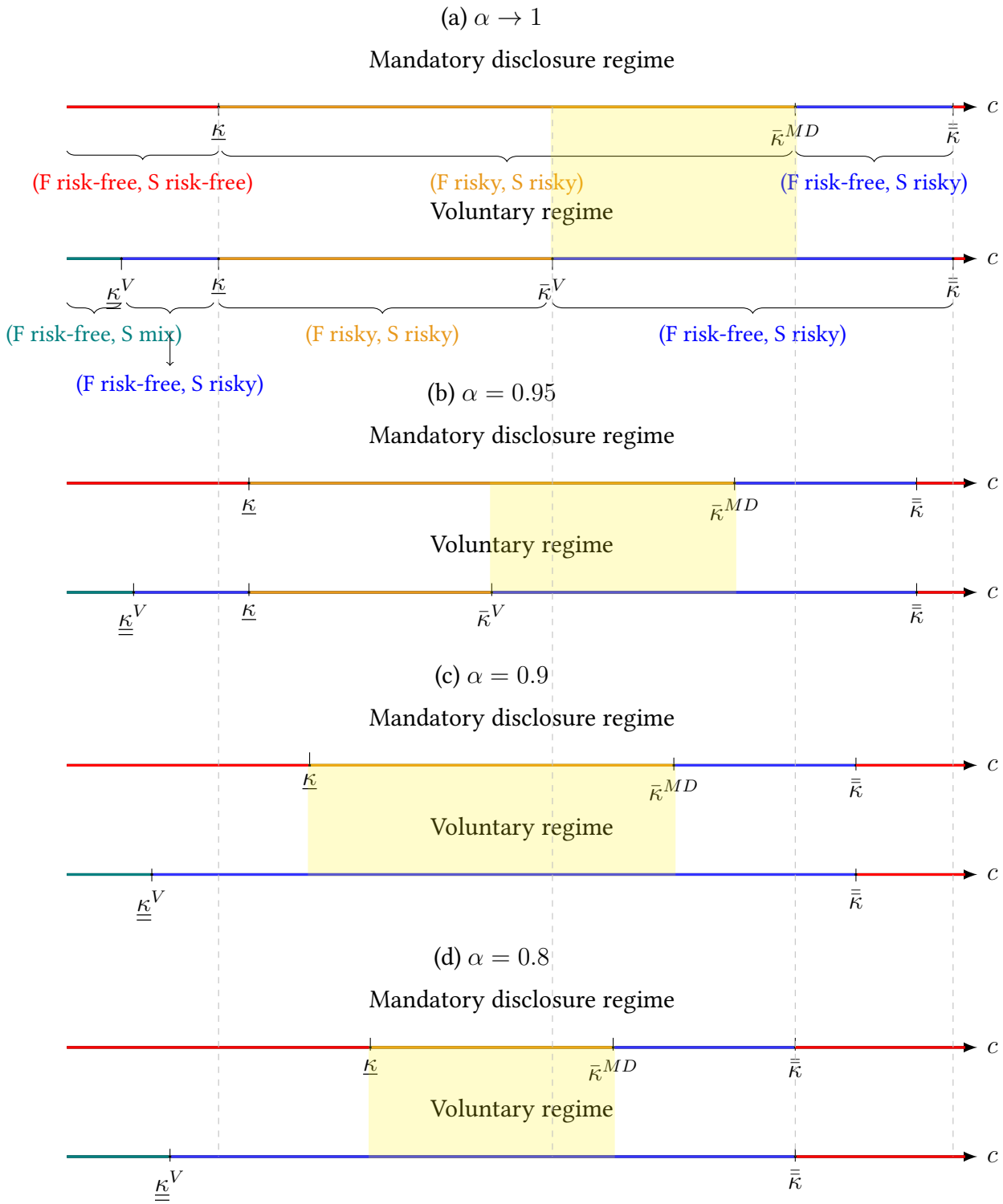
(3.1) *When $c < \underline{\underline{\kappa}}^{V}$, F selects the first-best risk-free project, discloses and certifies the received evidence of 1. S randomizes between the risk-free and risky projects, discloses and certifies the evidence when observing 1 or V, and withholds evidence when observing 0. The probability of S selecting the risk-free project, $\hat{\tau_S} \in (0,1)$, is given by the following:*

$$\hat{\tau}_S = 1 - \frac{(1-q)\left(qc(1-p) - (1-\alpha) - pq\alpha + pV(1-\alpha(1-q))\right)}{(1-p)q\theta(1-pV-qc(1-p))}. \tag{OA1}$$

(3.2) *When (a) $\underline{\underline{\kappa}}^{V} \leq c \leq \underline{\kappa}$ or (b) $c \geq \bar{\kappa}^{V}$, F selects the first-best risk-free project and S selects the risky project. Under Condition (a), F discloses and certifies her received evidence of 1. S discloses and certifies the evidence when observing V and withholds evidence when observing 0. Under Condition (b), F discloses the received evidence of 1 but does not certify the disclosure. S discloses and certifies the evidence when observing V and randomizes between misreporting 1 and withholding evidence when observing 0; the probability of S misreporting 1 when observing 0, $\psi \in (0,1)$, is given by the following:*

$$\psi = \frac{(1-\theta)(1-pq-p(1-q)V)}{(1-p)\left(1-\theta+p\theta(1-q)V\right)}. \tag{OA2}$$

(3.3) *When $\underline{\kappa} < c < \bar{\kappa}^{V}$, both F and S select the risky project and disclose and certify the evidence when observing V. However, when observing 0, F discloses 0 but does not certify it, while S withholds evidence.*



This figure plots the equilibrium project choices in the mandatory disclosure and voluntary regimes for different values of α in Panels (a)–(d). The other parameters are $p = 0.15, q = 0.5, \theta = 0.9$, and $V = 3.8$. The shaded area plots the region in which the voluntary regime dominates the mandatory disclosure regime in terms of investment efficiency.

Figure OA6: The extended economy where the manager has long-term incentives

Figure OA6 plots the investment efficiency in the extended economy where the manager has long-term incentives. Since the mandatory certification regime is always associated with the highest investment efficiency regardless of the values of α, we only plot the equilibrium project choices in the mandatory disclosure and voluntary regimes for different values of α.

First, within the same regulatory regime, Figure OA6 shows that as the firm manager becomes more concerned about the long-term firm value (α decreases), the investment efficiency improves. This is intuitive as one necessary condition for investment inefficiency is that the firm manager is concerned with the short-term stock price: due to the myopic incentive, the manager strategically manipulates the cash flow and information flow to affect investors' perception, resulting in investment distortion. As the manager's concern about the long-term firm value increases, she engages less in the manipulation, thereby improving investment efficiency.

Second, Figure OA6 shows that our principal result (i.e., the voluntary regime can dominate the mandatory disclosure regime in terms of investment efficiency) robustly holds if the firm manager is mainly concerned about the short-term stock price (high α).